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KANSAS ACADEMY OF SCIENCE

VOL. XXIX TRANSACTIONS

Semi-Centennial Volume

FIFTIETH ANNUAL MEETING
LAWRENCE
March 15 and 16, 1918

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PART I.—OFFICIAL.

CONSTITUTION OF THE ACADEMY.

SECTION 1. This association shall be called the Kansas Academy of Science.

SEC. 2. The objects of this Academy shall be to increase and diffuse knowledge in the various departments of science.

SEC. 3. The members of this Academy shall consist of two classes, active and honorary (including associate). *Active members* may be annual or life members. Annual members may be elected at any meeting of the Academy, and shall sign the constitution and pay annual dues of one dollar; but the secretary and treasurer shall be exempt from the payment of dues during the years of their service. Any person who shall at one time contribute twenty dollars to the funds of this Academy may be elected a *life member* of the Academy, free of assessment. Any member who has paid dues to the Academy for ten consecutive years, or who has been legally exempt during any portion of that time, may be elected a *life member* on the payment of ten dollars. Any member who has been a member of this Academy in good standing for twenty years may be elected a *life member* without payment of further fees or dues. *Honorary members* may be elected on account of special prominence in science, on the written recommendation of two members of the Academy. In any case, a two-thirds vote of members present shall elect to membership. Applications for membership in any of the foregoing classes shall be referred to a committee on applications for membership, who shall consider such application and report to the Academy before election.

SEC. 4. The officers of this Academy shall be chosen by ballot at the annual meeting, and shall consist of a president, two vice presidents, a secretary, and a treasurer, who shall perform the duties usually pertaining to their respective offices. The president, the secretary, and the treasurer shall constitute the executive committee. The secretary shall have charge of all the books, collections and material property belonging to the Academy.

SEC. 5. Unless otherwise directed by the Academy, the annual meeting shall be held at such time and place as the executive committee shall designate. Other meetings may be called at the discretion of the executive committee.

SEC. 6. This constitution may be altered or amended at any annual meeting, by a vote of three-fourths of attending members of at least one year's standing. No question of amendment shall be decided on the day of its presentation.

BY-LAWS.

I. The first hour, or such part thereof as shall be necessary, in each session, shall be set aside for the transaction of the business of the Academy. The following order of business shall be observed, so far as practicable:

1. Opening.
2. Reports of officers.
3. Reports of standing committees.
4. Appointment of special committees.
5. Unfinished business.
6. New business.
7. Reports of special committees.
8. Election of officers.
9. Election of members.
10. Program.
11. Adjournment.

II. The president shall deliver a public address on the evening of one of the days of the meeting, at the expiration of his term of office.

III. No meeting of this Academy shall be held without a notice of the same having been published in the papers of the state at least thirty days previous.

IV. No bill against the Academy shall be paid by the treasurer without an order signed by the president and secretary.

V. Members who shall allow their dues to remain unpaid for two years, having been annually notified of their arrearage by the treasurer, shall have their names stricken from the roll.

VI. The secretary shall have charge of the distribution, sale and exchange of the published Transactions of the Academy, under such restrictions as may be imposed by the executive committee.

VII. Eight members shall constitute a quorum for the transaction of business.

VIII. The time allotted to the presentation of a single paper shall not exceed fifteen minutes.

IX. No paper shall be entitled to a place on the program unless the manuscript, or an abstract of the same, shall have been previously delivered to the secretary.

PAST PRESIDENTS.

1869, 1870	B. F. Mudge.	1898	D. E. Lantz.
1871–1873	John Fraser.	1899	E. B. Knerr.
1874–1878	F. H. Snow.	1900	A. S. Hitchcock.
1879, 1880	B. F. Mudge.	1901	E. Miller.
1881, 1882	J. T. Lovewell.	1902	J. T. Willard.
1883	A. H. Thompson.	1903	J. C. Cooper.
1884, 1885	R. J. Brown.	1904	Edward Bartow.
1886	E. L. Nichols.	1905	L. C. Wooster.
1887	J. D. Parker.	1906	F. O. Marvin.
1888	J. R. Mead.	1907	J. A. Yates.
1889	T. H. Dinsmore, jr.	1908	E. Haworth.
1890	G. H. Failyer.	1909, 1910	F. B. Dains.
1891	Robert Hay.	1911	J. M. McWharf.
1892	E. A. Popenoe.	1912	F. W. Bushong.
1893	E. H. S. Bailey.	1913	A. J. Smith.
1894	L. E. Sayre.	1914	W. A. Harshbarger.
1895	Warren Knaus.	1915	J. A. G. Shirk.
1896	D. S. Kelly.	1916	J. E. Todd.
1897	S. W. Williston.		

OFFICERS OF THE ACADEMY, 1916.

President, J. E. Todd ..... Lawrence.
Vice President, Frank U. G. Agrelius ..... Emporia.
Vice President, L. D. Havenhill ..... Lawrence.
Treasurer, Wm. A. Harshbarger ..... Topeka.
Secretary Emeritus, J. T. Lovewell ..... Topeka.
Secretary, W. W. Swingle ..... Topeka.

EXECUTIVE COUNCIL.

Ex officio, the President, the Secretary, the Treasurer.

Elective for 1916.

J. A. Yates. J. M. McWharf.
A. J. Smith. J. A. G. Shirk.

OFFICERS OF THE ACADEMY, 1917.

President, FRANK U. G. AGRELIUS..... Emporia.
Vice President, BENNETT M. ALLEN..... Lawrence.
Vice President, L. D. HAVENHILL..... Lawrence.
Treasurer, WM. A. HARSHBARGER..... Topeka.
Secretary Emeritus, J. T. LOVEWELL..... Topeka.
Secretary, W. W. SWINGLE (to February 24, 1917)..... Topeka.
Secretary, H. WILSON SWINGLE (to December 31, 1917)... Topeka.
Secretary, GUY WEST WILSON (from January 1, 1918).... Lawrence.

EXECUTIVE COUNCIL.

Ex officio, the PRESIDENT, the SECRETARY, the TREASURER.

Elective for 1917.

LEROY HUGHBANKS, *Chairman.*
A. J. SMITH.
J. A. G. SHIRK.
J. M. MCWHARF.

Past Officers of the Academy.

Year	President.	First Vice President.	Second Vice President.	Secretary.	Treasurer.
1869	B. F. Mudge	J. S. Whitman		J. D. Parker	F. H. Snow.
1870	B. F. Mudge	J. S. Whitman		J. D Parker	F. H. Snow
1871	John Fraser	B. F. Mudge		J. D. Parker	F. H. Snow
1872	John Fraser	B. F. Mudge	R. J. Brown	J. D. Parker	F. H. Snow
1873	John Fraser	B. F. Mudge	R. J. Brown	J. D. Parker	F. H. Snow
1874	F. H. Snow	J. A. Banfield	J. D. Parker	John Wherrell	R. J. Brown
1875	F. H. Snow	B. F. Mudge	J. D. Parker	John Wherrell	R. J. Brown
1876	F. H. Snow	B. F. Mudge		Joseph Savage	W. M. Kedzie
1877	F. H. Snow	B. F. Mudge		Joseph Savage	W. K. Kedzie
1878	F. H. Snow	B. F. Mudge	J. H. Carruth	E. A. Popenoe	R. J. Brown
1879	B. F. Mudge	J. H. Carruth	Joseph Savage	E. A. Popence	R. J. Brown
1880	B. F. Mudge	J. H. Carruth	Joseph Savage	E. A. Popenoe	R. J. Brown
1881	J. T. Lovewell	J. H. Carruth	Joseph Savage	E. A. Popence	R. J. Brown
1882	J. T. Lovewell	J. H. Carruth	Joseph Savage	E. A. Popenoe	R. J. Brown
1883	A. H. Thompson	J. R. Mead	G. E. Patrick	E. A. Popenoe	R. J. Brown
1884	R. J. Brown	F. H. Snow	Joseph Savage	E. A. Popenoe	A. H. Thompson
1885	R. J. Brown	E. L. Nichols	G. H. Failyer	E. A. Popence	A. H. Thompson
1886	E. L. Nichols	J. D. Parker	N. S. Goss	E. A. Popence	I. L. Graham
1887	J. D. Parker	J. R. Mead	E. H. S. Bailey	E. A. Popenoe	I. D. Graham
1888	J. R. Mead	E. H. S. Bailey	T. H. Dinsmore, jr	E. A. Popenoe	I. D. Graham
1889	T. H. Dinsmore, jr	E. H. S. Bailey	G. H. Failyer	E. A. Popenoe	I. D. Graham
1890	G. H. Failyer	D. S. Kelly	F. W. Cragin	E. H. S. Bailey	I. D. Graham
1891	Robert Hay	F. W. Cragin	O. C. Charlton	E. H. S. Bailey	F. O. Marin
1892	E. A. Popenoe	F. O. Marvin	Mrs. N. S. Kedzie	E. H. S. Bailey	D. S. Kelly
1893	E. H. S. Bailey	J. T. Willard	E. B. Kneer	A. M. Collette	D. S. Kelly
1894	L. E. Sayre	I. D. Graham	J. L. Howitt	E. B. Kneer	D. S. Kelly
1895	Warren Knaus	I. D. Graham	S. W. Williston	E. B. Kneer	D. S. Kelly
1896	D. S. Kelly	S. W. Williston	E. B. Kneer	L. E. Sayre	
1897	S. W. Williston	L. E. Lantz	A. S. Hitchcock	E. B. Kneer	J. W. Beede
1898	D. E. Lantz	C. S. Parmenter	L. C. Wooster	E. B. Kneer	J. W. Beede
1899	E. B. Kneer	A. S. Hitchcock	J. R. Mead	D. E. Lantz	J. W. Beede
1900	A. S. Hitchcock	E. Miller	J. C. Cooper	D. E. Lantz	J. W. Beede
1901	E. Miller	J. C. Cooper	L. C. Wooster	D. E. Lantz	E. C. Franklin
1902	J. T. Willard	Edward Bartow	J. A. Yates	G. P. Grimsley	E. C. Franklin
1903	J. C. Cooper	Edward Bartow	J. A. Yates	G. P. Grimsley	Alva J. Smith
1904	Edward Bartow	L. C. Wooster	B. F. Eyer	G. P. Grimsley	Alva J. Smith
1905	L. C. Wooster	F. W. Bushong	W. A. Harshbarger	J. T. Lovewell	Alva J. Smith
1906	F. O. Marvin	B. F. Eyer	J. E. Welin	J. T. Lovewell	Alva J. Smith
1907	J. A. Yates	E. Haworth	F. B. Dains	J. T. Lovewell	Alva J. Smith
1908	E. Haworth	F. B. Dains	J. M. McWharf	J. T. Lovewell	Alva J. Smith
1909	F. B. Dains	J. M. McWharf	Alva J. Smith	J. T. Lovewell	F. W. Bushong
1910	F. B. Dains	J. M. McWharf	Alva J. Smith	J T Lovewell	F W. Bushong
1911	J. M. McWharf	Alva J. Smith	J. E. Welin	J. T. Lovewell	F. W. Bushong
1912	F. W. Bushong	Alva J. Smith	J. E. Welin	J. T. Lovewell	L. D. Havenhill
1913	Alva J. Smith	W. A. Harshbarger.	J. A. G. Shirk	J. T. Lovewell	L. D. Havenhill
1914	W. A. Harshbarger.	J. A. G. Shirk	J. E. Todd	J. T. Lovewell	L. D. Havenhill
1915	J. A. G. Shirk	J. E. Todd	F. U. G. Agrelius	J. T. Lovewell	L. D. Havenhill
1916	J. E. Todd	F. U. G. Agrelius	L. D. Havenhill	W. W. Swingle	W. A. Harshbarge
1917	F. U. G. Agrelius	L. D. Havenhill	B. M. Allen	W. W. Swingle H. W. Swingle Guy West Wilson	W. A. Harshbarger
1918	L. D. Havenhill	R. K. Nabours	B. M. Allen	Guy West Wilson	F. C. Bruchmiller

OFFICERS OF THE ACADEMY, 1918.

President, L. D. HAVENHILL ..... Lawrence.
First Vice President, ROBERT K. NABOURS ..... Manhattan.
Second Vice President, BENNETT M. ALLEN ..... Lawrence.
Treasurer, F. W. BRUCKMILLER (Resigned, July 10, 1918), Lawrence.
Secretary, GUY WEST WILSON ..... Lawrence.
Secretary Emeritus, J. T. LOVEWELL ..... Topeka.

EXECUTIVE COUNCIL.

Elective Members.

ALVA J. SMITH, Emporia.
J. M. MCWHARF, Ottawa.
J. A. G. SHIRK, Pittsburg.
W. A. HARSHBARGER, Topeka.

MINUTES OF THE FIFTIETH ANNUAL MEETING, KANSAS ACADEMY OF SCIENCE.

LAWRENCE, KAN., March 15, 1918.

The fiftieth annual meeting of the Kansas Academy of Science was called to order in the general lecture room of Snow Hall, University of Kansas, at 10:30 o'clock a. m., President Frank U. G. Agrelius in the chair.

After a few appropriate words of welcome by Dean L. E. Sayre, the Academy turned to the transaction of business. The usual reports were read and the standing committees appointed.

The treasurer made the following report:

Report of the treasurer to the Kansas Academy of Science for the year ending March 15, 1918:

Receipts:

Balance on hand, January 12, 1917	$770.99
Received from dues	32.00
Check returned by American Academy, Boston	.50
Interest on savings bank deposits	23.00
Total receipts	$826.49
Expenditures, as per check book submitted	186.29
Cash on hand	$640.20

Respectfully submitted,

W. A. HARSHBARGER, *Treasurer.*

After the business of the day was disposed of the Academy received delegates from other academies who were appointed to participate in our semi-centennial celebration. A number of congratulatory communications from other academies and from some of our own members were read. These greetings were ordered published in our Transactions.

The afternoon session was called to order by President Agrelius at 1:30 o'clock, p. m. After hearing greetings from additional academies the anniversary program was taken up. At the close of this the Academy with their friends and guests repaired to Brinken's Hall for the annual dinner, Prof. E. H. S. Bailey acting as toastmaster.

FRIDAY, MARCH 16, 1918.

The sessions of the Academy for the day were devoted to the general program of papers submitted. These numbered forty, all of which were presented by the authors, or read by title. The list of papers both for the Semicentennial Anniversary and for the general program is herewith presented.

Semicentennial Anniversary.

President's Address: A Half Century of Bacteriology. Frank U. G. Agrelius.

Symposium: Fifty Years of Scientific Development in Kansas.

The Academy of Science. W. A. Harshbarger.

Botany. L. C. Wooster.

Chemistry. E. H. S. Bailey.

Geology and Paleontology. Erasmus Haworth.

Zoölogy. W. J. Baumgartner.

The Early History of Medicine. J. W. McWharf.

The Early History of Pharmaceutical and Medical Chemistry. L. Sayre.

Lecture: Growth of Science during the Last Half Century. Prof. S. W. Williston, M. D., Ph. D., University of Chicago.

TITLES OF PAPERS SUBMITTED FOR FIFTIETH ANNUAL MEETING.

(In the order received by the Secretary.)

1. Occurrences of Black Flies in Louisiana during Recent Years. E. S. Tucker, Louisiana Agricultural Experiment Station.
2. Research Work with Insects Infesting Stored Rice. E. S. Tucker, Louisiana Agricultural Experiment Station.
3. Botanical Notes, 1917. Frank U. G. Agrelius, State Normal School, Emporia.
4. The Common Rocks and Gem-stones of Kansas and How to Recognize Them. M. M. Schmidt, Home City.
5. Hunting Dinosaurs on the Red Deer River, Alberta. Charles H. Sternberg, Lawrence.
6. The Moraines of Estes Park, Colorado. Lyman C. Wooster, State Normal School, Emporia.
7. Do Use and Disuse Modify Heredity? Lyman C. Wooster, State Normal School, Emporia.
8. A Probable Case of Superfetation in the Cow. Mary T. Harmon, Kansas State Agricultural College, Manhattan.
9. Abnormalities in the Central Nervous System of the Chick. Florence Alsop, Kansas State Agricultural College, Manhattan.
10. The Origin of Cyclones. A. A. Graham, Topeka.
11. The Genus *Strategus* of America North of Mexico. Warren Knaus, McPherson.
12. The New Kansas-Oklahoma Zinc Field. Arthur C. Terrill, University of Kansas, Lawrence.
13. Mineralography of the Comstock Ores. Arthur C. Terrill, University of Kansas, Lawrence.
14. On the Transmission of the Fowl Cestode, *Davinea cesticillus* (Molin). James E. Ackert, Kansas State Agricultural College, Manhattan.
15. Studies on a Modification of the Gram Stain. Noble P. Sherwood and Cora Downs, University of Kansas, Lawrence.
16. War Bread: Corn Starch and High Protein Flour Mixtures for Baking. L. E. Sayre, University of Kansas, Lawrence.
17. Corn Oil. L. E. Sayre, University of Kansas, Lawrence.
18. Coffee. L. E. Sayre, University of Kansas, Lawrence.
19. Aqueous Loess. J. E. Todd, University of Kansas, Lawrence.
20. Lacustrine Deposits near Atchison, Kan. J. E. Todd, University of Kansas, Lawrence.
21. Evaporation in Kansas. Charles A. Schull, University of Kansas, Lawrence.

22. *Entamœba bucali.* Nadine Nowlin, University of Kansas, Lawrence.
23. Sex Ratio and Pseudo-hermaphroditism in Amphibians. W. W. Swingle, University of Kansas, Lawrence.
24. Colloid Chemistry. C. F. Nelson, University of Kansas, Lawrence.
25. Recent Developments in Ore Dressing. Richard M. Grider, University of Kansas, Lawrence.
26. Further Experiments upon the Effect of the Glands of Internal Secretion upon Growth in Amphibia. Bennett M. Allen, University of Kansas, Lawrence.
27. *Physoderma zeæ*, a New Corn Disease in Kansas. L. E. Melchers, Kansas State Agricultural College, Manhattan.
28. A Report of the Plant Diseases in Kansas for 1917. L. E. Melchers, Kansas State Agricultural College, Manhattan.
29. The Water Relation of Corn and the Sorghums. E. C. Miller, Kansas State Agricultural College, Manhattan.
30. The Wamego Anticline. J. W. Beede, Austin, Tex.
31. The Algæ of the Water Supplies of Kansas. James B. McNaught, Water and Sewage Laboratory, State Board of Health, Lawrence.
32. A Preliminary List of the Algæ of Kansas. James B. McNaught, Water and Sewage Laboratory, State Board of Health, Lawrence.
33. Some Upper Pennsylvanian and Permian Crinoids. J. W. Beede, Austin, Tex.
34. The Migration of the Birds of Kansas. Mrs. Bessie Price Douthitt, University of Kansas, Lawrence.
35. The Fuel Situation in Kansas. E. H. S. Bailey, University of Kansas, Fuel Administrator of Douglas County, Lawrence.
36. Correlation of the Formations Described in the Fort Apache Region in Arizona with Similar Formations in other Parts of the State. Albert B. Reagan, Fredonia.
37. The Mine Center District, Ontario. Albert B. Reagan, Fredonia.
38. The Flora of the Olympic Peninsula, Washington. Albert B. Reagan, Fredonia.
39. Contributions of the Drug Laboratory of the University of Kansas to the Enforcement of the Food and Drug Laws. G. N. Watson, University of Kansas, Lawrence.
40. Plague of Cholera Infantum at Nett Lake, Minnesota, in the Fall of 1913. Albert B. Reagan, Fredonia.

After listening to the usual committee reports and the election of members, and electing officers for the ensuing year, the Academy adjourned.

The detailed report of the meeting, together with the report of the secretary, have been published as Bulletin No. 3 of the Academy.

GUY WEST WILSON, *Secretary.*

Report of the Delegate to the Illinois Academy of Science.

To the Kansas Academy of Science: My visit to the meeting of the Illinois Academy of Science in Galesburg, at the request of your body, on February 22-23, 1917, was of special value in that it gave an opportunity to investigate the work that is being carried on by other Academies, so that we may improve the conditions at home.

The histories of these Academies of Science are of interest. One of the first academies to be established was that of Connecticut, which was

incorporated in 1799. It has dues of $5 a year and receives an annual appropriation of $1,500 from Yale University. This academy has monthly meetings and its reason for existence is for the purpose of exchange, library facilities, and publication. Another of the early institutions of this kind was the Philadelphia Academy of Science, established in 1817, and endowed, but collecting an annual fee of $10 from its members. This academy has a museum and library, both very valuable.

The consideration of state academies shows that they are established under various auspices, although they have a common aim—that of the dissemination of scientific knowledge, the collection of scientific material in a museum, the establishing of a library, and the publication of scientific work of the members. Some of these academies are primarily natural history societies, more especially that of Ohio and that of California. Most of the state societies have annual dues of $1, and hold an annual meeting. In the case of some of these the proceedings are published by the state, while in other cases they are either privately published by the academy from its own funds, or from the proceeds of the endowment of the academy.

With reference to the Illinois academy it should be said that the scientific men of the state, without exception, take an active interest in it. Its officers are chosen from the professors in the University of Chicago, Northwestern University, James Milliken University, University of Illinois, Illinois Wesleyan, the Chicago high schools, and several of the normal schools and colleges. It should be noted that the very best men in the state and those who are leaders in scientific thought in the state, like Professor Forbes of the University of Illinois, Professor Coulter of the University of Chicago, and Professor Crew of Northwestern University, are among the officers and workers in this academy. The scientific men of Illinois seem to realize that it is worth while to maintain an academy to act as a clearing house for the scientific work of the state. They are willing to do this at the sacrifice of both time and money. The getting together of the scientific men of the state institutions, the colleges, normal schools, and leading high schools in some college town every year seems to be a success, and these different institutions are working harmoniously together. Although they are covering a large field of scientific investigation, each man is interested in the investigations of his colleagues and is doing everything possible to advance the scientific interests of the state.

In order to further interest in our Academy, I would recommend:

(1) A more active canvass for members, until we get practically all our scientific workers enrolled.

(2) The calling of the annual meeting in the larger college towns, rather than in Topeka.

(3) That a special effort be made to get the *leading scientific men of the state* to consider the academy one of their own activities and to help to direct its policy. Respectfully submitted. E. H. S. Bailey.

PART II.—FIFTIETH ANNUAL MEETING. SEMICENTENNIAL PROGRAM.

List of Delegates to the Semicentennial Celebration of the Kansas Academy of Science from Other Academies.

Connecticut Academy of Arts and Sciences: *Prof. William L. Burdick, Ph. D., University of Kansas, Lawrence, Kan.

National Academy of Science: Prof. Samuel W. Williston, M. D., Ph. D., Sc. D., University of Chicago, Chicago, Ill.

Academy of Natural Sciences of Philadelphia: Prof. Samuel W. Williston, M. D., Ph. D., Sc. D., University of Chicago, Chicago, Ill.

New York Academy of Sciences: Dean H. von W. Schulte, M. D., Creighton University, Omaha, Neb.

Torrey Botanical Club: *Prof. Raymond J. Pool, Ph. D., University of Nebraska, Lincoln, Neb.

Iowa Academy of Science: Prof. J. E. Todd, M. A., University of Kansas, Lawrence, Kan.

Indiana Academy of Science: *Prof. Mary T. Harman, Ph. D., Kansas State Agricultural College, Manhattan, Kan.

Ohio Academy of Science: Prof. George E. Coghill, Ph. D., M. D., University of Kansas, Lawrence, Kan.

Illinois Academy of Science: Prof. Samuel W. Williston, M. D., Ph. D., Sc. D., University of Chicago, Chicago, Ill.

South Dakota Academy of Science: Prof. T. E. McKinney, Ph. D., University of South Dakota, Vermilion, S. D.

Greetings to the Kansas Academy of Science upon the Occasion of the Semicentennial Celebration.

THE AMERICAN PHILOSOPHICAL SOCIETY.

PHILADELPHIA, March 2, 1918.

The Secretary of the Kansas Academy of Science, Lawrence, Kan.:

SIR—I am instructed by The American Philosophical Society to express to the Kansas Academy of Science its cordial congratulations on the occasion of its semicentennial anniversary, and to express its regret that the distance renders it impracticable for a member of the society to be present and express them on its behalf.

I have the honor to be, my dear sir,

Your obedient servant,

I. MINIS HAYS, *Secretary.*

*Not present.

AMERICAN ACADEMY OF ARTS AND SCIENCE.

CAMBRIDGE, MASS., March 14, 1918.

Secretary, Kansas Academy of Science, Lawrence, Kan.:

On behalf of the American Academy of Arts and Science I have to acknowledge the courteous invitation of the Kansas Academy of Science to be represented by a delegate at its semicentennial anniversary. I regret that it has proved impracticable to arrange for such representation. The Academy hereby tenders congratulations and best wishes.

H. W. TYLER, *Corresponding Secretary.*

THE CONNECTICUT ACADEMY OF ARTS AND SCIENCES.

Represented by Prof. William L. Burdick, Ph. D.

THE ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA.

PHILADELPHIA, March 4, 1918.

To the Secretary, Kansas Academy of Science, Lawrence, Kan.:

The Academy of Natural Sciences of Philadelphia acknowledges with appreciation the invitation of the Kansas Academy of Science, and begs to extend its congratulations on past accomplishments and felicitations upon future promise of the Kansas Academy.

If possible a delegate will be sent to the meeting.

On behalf of this Academy, I have the honor to be,

Yours most respectfully, J. PERCY MOORE,

Corresponding Secretary.

The delegate sent was Prof. Samuel W. Williston, Ph. D., M. D., Sc. D.

NEW YORK ACADEMY OF SCIENCES.

Represented by Dean H. von W. Schulte, M. D., Creighton University, Omaha.

Mr. President, Ladies and Gentlemen: It is with great pleasure that I am here to bring you the greetings and congratulations of the celebration. It is but a short time since the New York academy has observed its hundredth anniversary simply and quietly, but with high resolve as benefits these critical years of war, and the good will and best wishes of its members go forth to you with more than ordinary feeling, not merely as to a like-minded body of scientific men, but even more as to an agency in the service of our country in the time of trial. Both societies have given of their membership largely to the national cause; many are in active service, many engaged in special work. It is important that those who cannot from various causes render such direct service, to remember that upon them also devolve important duties. For we are not alone engaged in suppressing an abominable attack upon culture and civilization; it is also incumbent upon us to demonstrate the superiority of democracy in every field of human endeavor. Those of us who believe that the sciences are at the very root of national prosperity and human progress must prove ourselves no sluggards now. Our universities, our colleges and the community at large, have given the young and strong, the promise of a whole generation, to this great struggle.

It is more than ever important that those who continue in their wonted work should realize that they are set apart to see that the great structure of our educational system sustain no detriment so that increased zeal and devotion may compensate for diminished numbers in the maintenance of our institutions and the prosecution of scientific advance. It is well, therefore, that societies such as the Kansas Academy of Science, with long records of achievements in the service of the state, should gather and meet together, to draw inspiration from the past and courage for the work in hand. In the name of the New York Academy of Sciences, I greet you and bid you God-speed.

TORREY BOTANICAL CLUB.

Represented by Prof. Raymond J. Pool, Ph. D., University of Nebraska, Lincoln.

NATIONAL ACADEMY OF SCIENCES.

WASHINGTON, D. C., March 7, 1918.

The Secretary, The Kansas Academy of Science, Lawrence, Kan.:

DEAR SIR—The National Academy of Science congratulates the Kansas Academy of Science upon arriving at the semicentennial anniversary of its existence and desires to express hope that the results of research work of its members in the future will be even greater than those which have already become a part of the scientific history of Kansas.

It is regretted that the National Academy of Science is unable to accept the invitation of the Kansas Academy of Science to send a delegate, on account of the war conditions and the necessity for so many of its members to be on active duty in connection with war service.

Very respectfully yours,

ARTHUR L. DAY, *Home Secretary.*

The academy was represented by Prof. Samuel W. Williston, M. D., Ph. D., Sc. D., University of Chicago.

PHILOSOPHICAL SOCIETY OF WASHINGTON.

WASHINGTON, D. C., March 7, 1918.

The Secretary, Kansas Academy of Science, Lawrence, Kan.:

DEAR SIR—The Philosophical Society of Washington has received the notice of the semicentennial anniversary meeting of the Kansas Academy of Science, and the invitation to send a delegate to this meeting.

The Philosophical Society, through its general committee, wishes to extend congratulations to the Academy and to wish it a long continuation of its useful career. I regret to say, however, that the Society will be unable to send a dalegate.

Very truly yours, E. C. CRITTENDON,
Corresponding Secretary.

COLORADO SCIENTIFIC SOCIETY.

DENVER, COLO., February 26, 1918.

Secretary, Kansas Academy of Science, Lawrence, Kan.:

MY DEAR SIR—I desire to acknowledge, on behalf of the Colorado Scientific Society, your very kind invitation to send a delegate to Lawrence to represent our Society in the semicentennial anniversary of the Kansas Academy of Science. If it is at all possible for me to do this I will do so; and meanwhile I desire to congratulate your Society, on behalf of the Colorado Scientific Society, and to wish you every success in your meeting and the advancement of science in your state.

Very sincerely yours, R. B. MOORE, *President.*

ELISHA MITCHELL SCIENTIFIC SOCIETY.

CHAPEL HILL, N. C., March 8, 1918.

The Elisha Mitchell Scientific Society appreciates the kind invitation to be present at the semicentennial anniversary of the Kansas Academy of Science but finds it impossible to send a delegate.

With greetings and best wishes,

THE ELISHA MITCHELL SCIENTIFIC SOCIETY,
FRANCIS P. VENABLE, *Secretary.*

IOWA ACADEMY OF SCIENCE.

Represented by Prof. J. E. Todd, A. M., University of Kansas, Lawrence.

To the Members of the Kansas Academy of Science:

I come to your semicentennial celebration as delegate from the Iowa Academy of Science, of which I was a charter member and for many years a corresponding member.

I bring you the hearty congratulations of your sister society. Our two societies have several things in common. Some of our former members have from time to time become identified with you, as Doctors Patrick and Haworth, and others. We are both in the Middle West, both in leading agricultural states with important mines in coal and lead with some gypsum. We can therefore appreciate more fully and value more accurately the scientific zeal, wisdom and efficiency indicated by the fact that you, in a considerably younger state, are preceding us by several years in celebrating your jubilee year.

We therefore cheerfully recognize this preëminence on your part, and will count ourselves fortunate if on our fiftieth year we find our published proceedings as varied and practical and our work as fully appreciated and supported by the state.

We congratulate you most sincerely.

INDIANA ACADEMY OF SCIENCE.

Represented by Prof. Mary T. Harman, Ph. D., Kansas State Agricultural College, Manhattan, Kan.

MANHATTAN, KAN., March 14, 1918.

Mr. Guy West Wilson, Secretary Kansas Academy of Science, Lawrence, Kan.:

MY DEAR MR. WILSON—I received word from the Indiana Academy of Science stating that I should be their official representative at the

fiftieth anniversary of the Kansas Academy of Science. I am very sorry to say that I cannot be there in person, largely owing to the illness of my mother, but, on behalf of the Indiana Academy of Science, I extend greetings to the Kansas Academy of Science, expressing the hope that it will continue to fill the place in the scientific world which it has done previously. Very sincerely yours, MARY T. HARMAN,

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OHIO ACADEMY OF SCIENCES.

DELAWARE, OHIO, March 13, 1918.

Secretary, Kansas Academy of Science, Lawrence, Kan.:

Hearty congratulations from Ohio Academy to the Kansas Academy on the completion of your half century of service. We are asking Professor Coghill of your university and formerly one of our members to represent us. EDWARD L. RICE, *Secretary.*

Prof. George E. Coghill, Ph. D., M. D., University of Kansas, Lawrence, as delegate of the Ohio Academy of Sciences gave their greetings.

MICHIGAN ACADEMY OF SCIENCE.

KALAMAZOO, MICH., March 12, 1918.

Secretary Kansas Academy of Science, Lawrence, Kan.:

DEAR SIR—Replying to your kind invitation of February 5, which has just come to hand, I am sorry to state that it will not be possible for us to send a delegate to your semicentennial anniversary, though we should be only too happy to join you in your celebration were it possible.

May I take this opportunity to extend to the Kansas Academy greetings and best wishes from the Michigan Academy of Science and to wish you another half century of as equally valuable scientific work as stands to your credit for past labors. Kansas has given many splendid men to the field of science and I am sure that the Academy has been no small factor in this output.

Very cordially yours, LEROY H. HARVEY, *President.*

NORTH CAROLINA ACADEMY OF SCIENCE.

GREENSBORO, N. C., February 27, 1918.

The North Carolina Academy of Science offers hearty congratulations to the Kansas Academy on its semicentennial anniversary and sends best wishes for another fifty years of scientific endeavor and progress. The North Carolina Academy returns thanks for the invitation to attend this anniversary and regrets that distance makes it impossible for it to send a delegate. For the Academy, E. W. GUDGER, *Secretary.*

THE SOUTH DAKOTA ACADEMY OF SCIENCE.

Represented by Prof. T. E. McKinney, Ph. D., University of South Dakota, Vermilion, S. D.

MR PRESIDENT—Coöperation and organization are necessary to the rapid advancement of science. This truth finds expression in the existence of the scientific societies of the world; in none more certainly than in the state academies of science. Here are grouped the scientific workers of the state to contribute each according to his ability to the increase of

knowledge, with particular reference, perhaps, to that phase which at the time may be especially useful to the people of the commonwealth and helpful in its administration. In bearing greetings of good will from the South Dakota Academy of Science to the Kansas Academy of Science on this your semicentennial anniversary, permit me to mention the honorable part your Academy has had in the extension of the boundaries of knowledge and in making possible its useful application within your state. Further, your Society has been as a mother to many young and ambitious workers in science. With admiration for your achievements and a desire to emulate them in her first fifty years, the youngest of the state academies extends warmest greetings and best wishes for the future to the Kansas Academy, believing that despite her fullness of years she is but on the threshold of a long and honorable career, to be enriched by many discoveries of the highest order in science, conferring blessings on the people of your state and contributing much to the progress of civilization.

SOCIEDAD CIENTIFICA "ANTONIO ALZATE."

MEXICO, 7 de Marzo de 1918.

Sr. Secretario de la Kansas Academy of Science, Lawrence, Kan.:

MUY SR. MIO—Esta Sociedad he recibido la atenta invitación de Ud. de fecha 15 de Febrero próximo pasedo, para que se haga representar en la celebración del Quincuagésimo Aniversario de la fundacion de esa Academia, que tendrá lugar en la Universidad de Kansas los días 15 y 16 del presente.

En la imposibilidad de nombrar una persona que concurra a esa interesante ceremonia, debido a la premura del tiempo, la Sociedad se ve privada de esa honora, y hance votos sinceros y fervientes por la prosperidad y desarrollo de esa Academia.

Envío a Ud. Sr. Secretario en nombre de la Sociedad, sus calurosas felicitaciones, y me ofrezco su atento, afmo. S. S.

R. AGUILAR, *Secretario.*

DIRECTION DE ESTUDIOS BIOLOGICOS.

MEXICO, Marzo 7, 1918.

Sr. Presidente de la Kansas Academy of Science, Lawrence, Kan.:

Direction Estudios Biologicos dependiente de Secretaria Agricultura y Fomento acepta agradecida invitacion enviar deligado mitin efectuarase dias quince y diecise is actual para celebrar quincuagésimo aniversario fundacion esa Academia y ruega a usted dignese reprentarla atendamente. El Director de Estudios Biologicos, A. L. HERRERA.

GREETINGS FROM ABSENT MEMBERS.

912 E. SAN MIGUEL ST.,
COLORADO SPRINGS, COLO., March 14, 1918.

To My Old-time Associates in the Kansas Academy of Science, and to All Fellow Members of the Academy, Greeting:

I much regret that I cannot be with you on this most interesting and notable occasion, but I rejoice with you in the Academy's attainment of that mature age at which it can celebrate its fiftieth annual meeting.

The Academy may well feel proud of its achievements, not only in the quantity of its published work, and in the scientific collections and library it has built up, but also and especially in the stimulus immeasurable that

it has been to scientific research, both within and beyond the boundaries of Kansas.

As a life member of the Kansas Academy of Science, I am glad to report that I am still engaged in scientific research, although chiefly in geography and archeology as related to the early western history, on which I have, nearing completion, three volumes, whose rigorous pressure on my time and means has been the cause of my inability to attend this Academy meeting. But my heart is with you.

Last August, in Phœnix, I met the son and daughter of an early and beloved officer of the Academy, who gave me a most hearty welcome, simply because I had been in academic association with their lamented father, good old Doc Brown, of Leavenworth.

When shall we older members ever forget such men as Snow, Parker, Savage, Thompson, Popenoe, Dyche, Goss, Kellerman, Smyth, Meade, and other departed ones who used to keep the Academy pot boiling?

And who can measure the momentum given to the Academy by such men as Mudge? The latter I never saw, but I knew of him in '75-76, when receiving (under the friendly tutelage of Popenoe and the encouragement of Professors Merril and Dunbar of Washburn College I "prep'd" in from '72) my first really scientific initiation into natural history, a love for which I had inherited from a Granite State sire of my name, a Dartmouth M. D., 1830—who had practiced medicine in Surinam from 1830 to 1857, being consul at Paramaribo *part* of that time, and sending creatures of all sorts thence nearly *all* of that time, to the Boston Society of Natural History.

And who can be grateful enough to Secretary Gray, of that board, for taking the Academy, in its downy days, under the sheltering wing of the Kansas State Board of Agriculture? Few of the "old guard" are left.

Long live the memory of these men, and as they are followed by zealous successors, *Long live the Kansas Academy of Science!*

Fraternally yours, FRANCIS W. CRAGIN.

ITHACA, N. Y., March 5, 1918.

Mr. Guy West Wilson, Secretary of the Kansas Academy of Science, Lawrence, Kan.:

DEAR SIR—It is a great regret that I shall be unable to attend the fiftieth annual meeting of the Kansas Academy. Pray extend my congratulations upon its semicentennial occasion to the members of the Academy, my active connection with which afforded me great pleasure during my residence as a member of the faculty of the State University.

Yours very truly, EDW. L. NICHOLS.

MADISON, WIS., March 14, 1918.

Guy West Wilson, Lawrence, Kan.:

Extend my congratulations and best wishes to Academy on its fiftieth anniversary. Would enjoy being with you among old-time colleagues and friends, but duties in state war service make it impossible.

GEO. WAGNER.

TALLULAH, LA., March 13, 1918.

DEAR SIR—My congratulations for the fiftieth anniversary of the Academy! May it endure! Regretting that I cannot attend, I remain,

Sincerely, E. S. TUCKER.

A Half Century of Bacteriology.

PRESIDENTIAL ADDRESS, 1918.

FRANK ULYSSES GRANT AGRELIUS, President, 1917-'18.

Of all living things, those that are the smallest are probably the most important. This may not be literally true, but we venture the assertion that it is a close approximation to the truth. And we would venture another statement of about equal breadth: That the nation or people that acts in harmony with the most advanced knowledge of bacteriology will have a great advantage in the world; and that, on the other hand, the group that orders its affairs contrary to such wisdom is as certainly doomed to decline. It is partly because of this belief that I have chosen to discuss what I consider one of the most remarkable and at the same time a most encouraging record of man's achievement.

We know of no field of human endeavor in which the prophecy, "Ye shall know the truth, and the truth shall make you free," more aptly applies than in that of man and his relation to bacteria and other germs. For untold ages of time he had been enslaved by insidious enemies, scourged by tyrannical foes, thwarted again and again in his endeavors by forces more powerful than he. At the same time other myriads of beings were toiling industriously that soil might exist in which green plants could grow and furnish food for themselves and all other living things. Man now knows that countless tiny, but nevertheless powerful and harmful, germs are at all times ready to cause him suffering and often death, and that they are a real thing to be avoided, or their work counteracted. He also knows that probably many more germs are much more industriously toiling for him in many ways, and that without these latter he could not exist on the earth. Furthermore, and what is very important, he is learning that there are many ways in which he may avoid the possible harm from the one class, and that he may make even greater use of the other helpful class.

Another peculiar fact in connection with this science is that it has made practically its entire growth since that time, the fiftieth anniversary of which we celebrate in this session. Not only this, but very much of this development has been made in a much shorter period than fifty years.

One cannot take up a discussion such as this without seeing the rather odd fact that to one man alone it has come to lay by far the greater portion of the foundation of such an important science. The world is indebted to Louis Pasteur for a large proportion of the fundamental facts upon which the science of bacteriology rests, and through this such a far-reaching amelioration of conditions that it may well style him "The World's Helper."

Fifty years ago Pasteur had found the cause and cure of the two serious diseases of the silk worm and a cause of the souring of milk. He had done considerable work with the fermentation of various substances, showing that such changes were due to the activities of minute

organisms. He had overthrown the doctrine of spontaneous generation as then understood. We should add, parenthetically, that Jenner had done an important act in discovering or applying properly the principle of smallpox vaccination. He had done this in 1798. But we will leave this, granting that much credit is due Jenner for it. From the observations of Pasteur mentioned there followed Lister's work which, when the Kansas Academy of Science was established, was largely in process of growth and demonstration. In 1867 he published a record of eleven cases of compound fracture treated antiseptically. We see then that this society is as old as antiseptic surgery. It follows that some of the fundamental facts of the science were known. However, the great mass of the discoveries of fact, and the invention and improvement in technique, were made well along in this period, and no small part has been accomplished within the last two decades.

We wish now to note another peculiar thing, and it is this: Man has often learned and made use of many practical facts when he had but a very imperfect knowledge of the fundamental principles in the case. We have referred to vaccination. This was practiced in England in the eighteenth century and probably long before this in China, but it was little understood. Jenner elaborated upon it, but it is not even now certain as to the real facts in the case. Man early learned also to be careful in the disposal of excreta, and with the bodies of dead animals. He was somewhat careful with his drinking water. He avoided the sick to some extent. He was even suspicious of the well from the point of view of his health. It has long been considered a deadly insult for one to spit upon another. Especially was it so regarded for one to do this in the other's face. It is reasonable to suppose that this may have come about from a slowly developed intuition of the possibility of contagion in such cases. Most boys have been cautioned not to lie around sluggish streams in the heat of the summer, and most of us have been told of the dangers of night air.

We should not wonder at these vague notions, especially when we consider the great difficulty of knowing and understanding organisms as small as many germs. Pasteur accomplished his early work by the aid of the compound microscope. There are even now many difficulties in the way of one who would study bacteria.

But to take up the main thread again. In 1876 Koch proved that anthrax in cattle is caused by a specific germ—*Bacterium anthracis.* He also advanced his rules of procedure in determining the cause of any germ disease. These are "Koch's laws": (1) The germ must be found present in the typical disease. (2) It must be isolated and grown in pure culture. (3) It must produce when introduced in pure culture into the body of the normal animal or plant the typical disease. (4) It must again be isolated from the diseased organism. These laws have been rather closely observed, and show with what care science advances before pronouncing any dictum.

But to follow these laws is easier said than done. It is often not easy to isolate an unknown germ. It is very difficult even to find them sometimes, and it is quite probable that some are still invisible. Paul

Ehrlich has done much in the discovery and application of stains. Others of course have helped. Staining, especially when differential or contrasting so that the bacterium will be differently colored from its surroundings, has enabled experimenters to see germs where they would otherwise have been invisible.

Koch himself performed a strictly fundamental thing when he invented the use of gelatine as a part of media. This rendered rather easily possible in many cases the isolation of a pure culture by entrapping the germs, and requiring them to develop at points isolated from one another. Other media having a similar purpose are now made. Our own Professor Barber went a step farther and to a nicer conclusion in making possible the isolation of a single germ by his method of the very small pointed capillary pipette. It may interest some to know that Professor Koch did not have much faith in Professor Barber's device until he was shown it in use. Then he gracefully acknowledged his sin of unbelief and atoned by ordering some of the improved apparatus.

Many different practices are now followed in obtaining pure cultures. These include animal inoculation where, in specific cases, the animal will destroy all but the one kind of germ and it will then be found in pure culture in some part of the animal body. Other methods have for their purpose the same end through a gradual elimination of those germs not wanted and of the enrichment of the culture in the one desired, as in the use of malachite green-agar by Löffler to secure typhoid germs. Then there are differential media, such as Endo's, for the differentiation of *B. typhosus* from *B. coli.*

However, isolation is not the whole matter. It is often very difficult to make bacteria grow at all, and a vast amount of study and experimentation has resulted in a very great variety of media and of much better understanding of the nature of bacteria and of the food requirements of various kinds. It may be noted that the requirement varies from the purely mineral to practically a need for the living protoplasm of some very closely limited species of plants or animals.

And after recognizing the task assumed in applying the first two of Koch's laws we are still not through with our difficulties. Often a germ is harmless to an animal unless some peculiar method of inoculation is used or some more or less exceptional condition of the animal is to be induced. Tetanus germs are ordinarily harmless when taken into the stomach, and again they may prove harmless when placed in the flesh in pure culture. When accompanied by ærobes in the latter plan they are much more serious. Typhoid bacteria fed to one person could easily cause typhoid fever, but in one who for any reason is immune to it they would produce no noticeable effect. Koch's laws are good laws, but their demonstration is often very difficult, and still the undoubted causes of many diseases have been proved and these laws yet observed.

The use of gelatine media was announced in 1882. In May, 1881, another milestone in this science had been reached. Pasteur, working near Melun, France, inoculated fifty sheep (really some were goats)

with virulent anthrax germs. He had protected twenty-five with attenuated anthrax bacteria, but had left the others unprotected. It was a case of Elijah and the priests of Baal, for here he was to demonstrate to many disbelieving scientists and others his claims regarding a matter of truth and falsity. The figure could be carried further. On the second day following a great crowd was present. Twenty-two of the unprotected animals were dead, two were dying, one was sickening. All of the twenty-five protected ones were in good health. This one practice, demonstrated here, has saved France many millions of dollars annually. But what is more important, it laid the foundation for an immense amount of investigation of the whole question of immunization against disease.

Probably next to that of Pasteur, Paul Ehrlich has done more to explain the mechanism of immunity than any other man. In the later years of the last century (1897) he advanced what is known as "Ehrlich's Receptor Theory." This asserts that cells are able to utilize the food substances present in the blood by means of certain attributes similar to the "side chains" of the "benzine ring." When for any reason these side chains, or cell-receptors, are destroyed, but the cell not killed, there is an overproduction of receptors, and these, cast off into the blood, are the antitoxins and other antibodies often found in the animal body.

Whether true or not this idea has been very fruitful in explaining many cases of immunity, and in suggesting proper lines of procedure for further attempts at immunization. Of these more later.

Metchnikoff advanced the so-called "phagocyte theory," and to Wright is due the greater credit for the application of this theory in his work on the "opsonic index." This theory often explains the presence or absence of immunity, and its loss or acquirement, as for instance in tuberculosis. It throws light on the question of the crises that occur in diseases, and often is a guide to the physician in his treatment of various ailments.

The discovery of the precipitins formed by bacterial action has given man a fine instrument to assist him in determining relationships between animals, and also enables the law to pronounce accurate judgment upon the testimony of persons concerning the source of blood stains and meat products. These and other matters of technique are modern parallels of Solomon's wisdom in using the bees in distinguishing between the real and the artificial flowers.

Through the principle of complement fixation it is now possible to determine with considerable certainty whether one is or has been the carrier of *Treponema pallidum*, the cause of syphilis, and through the agglutinins it can be determined whether one is or has been recently affected by *B. typhosus*—the "Widall reaction." Of course this is not all of the ways in which these specific discoveries can be and are applied, but are simply illustrations.

The peculiar phenomenon known as "Anaphylaxis," or protein sensitization furnishes an explanation of the effect of typhoid bacteria upon the body, and of immunization acquired by typho-bacterin treatment. It also explains immunization by vaccination as in smallpox. The body

produces an antibody—an antienzyme—for certain proteins present in the typhoid bacili, and in the organism or whatever it may be that causes smallpox.

The technique and subject matter of the science has now become so broad and complicated that in it, as in many other sciences, it is necessary to specialize along many different lines, and of course there is no probability that the end is near.

The influence of the science is now felt in numerous paths of activity, and naturally it invokes the aid of many other branches of learning. Its greatest influence is probably exerted in medicine, but it likewise furnishes much of the subject matter in other professions or occupations. Only a few of these will be named.

In agriculture we see that the richness of the soil is due to the decay of organic substances, and that this is brought about in the main by bacteria. We know that the destruction of these things is often decidedly unwelcome, but it is, nevertheless, a beneficent and entirely necessary process. Otherwise the needful elements, such as nitrogen, stored up in the bodies of plants and animals, would very tardily be again available for our use. Nature would then be a genuine miser, taking the necessary elements of life and activity out of circulation. It is thus seen that our very life is dependent upon death and decay. Again, bacteria add nitrogen to the soil from the great ocean of it in the air. Others help to render certain substances available for plants. Sulphur, phosphorus and others are included in this list. But others, like the Prodigal Son, are ready to waste the needful substances of the soil, and will do so if not controlled. These facts added to others, such as the loss of living plants and animals and various farm products, bring the farmer face to face with the necessity of an understanding of bacteria.

This leads us to a realization of the fact that man from time immemorial has had to struggle to keep foods obtained in excess of need at certain times or places to the time or place in which the order of need and acquirement shall have changed places. Bacteria of decay have largely been the occasion of this, and our great canning and other food-preserving industries are the result. It is quite evident that man was intended to live by the sweat, not only of his brow, but of his intellect as well.

We are led further again, this time to see a connection between bacteriology and commerce. The thousands of refrigerator cars will illustrate our point. Quarantine regulations against bubonic plague and Texas fever are others. Our experience with foot-and-mouth disease is quite fresh in memory.

The principles of bacteriology have had a great influence on hygiene and sanitation, and these subjects consist largely now of rules, the need for which was made apparent by the facts of this science. These again ramify through all of the avenues of life. They may be said to reach from one extreme to another—all the way from the drainage of land, the construction of buildings of all sorts, to the sentiments expressed in kissing. They range from table etiquette to the disposal of sewage; from even before the birth of a child to the disposal of the body after

death. Further mention will be made in a consideration of specific disease to follow later.

In contending with diseases caused by germs several matters are of prime importance. Among these are the discovery of the causal microbe, its isolation, a study of its growth and physiological characteristics, its distribution in nature, the modes of infection, and the means of immunization against it. The more completely these factors are known, the more effectually we may control it. Truly marvelous results have been accomplished. It should be noted here that "Peace hath her victories no less renowned than those of War," and that these are often bought for a price as in war. More than one person has risked and even lost his life voluntarily in this line. The number of lower animals that have been sacrificed is legion.

The means of combating smallpox have long been known. When applied the results have proved their efficiency. In Germany since 1874 all infants must be vaccinated during their first year, and again at the age of twelve. Since that date long periods have passed without any deaths in the empire, and this with a constant introduction of the disease from without. In the German army up until recently there have been only two deaths from this disease since 1874. One of these was a reservist who had not been successfully vaccinated. Contrast this with the following. It is estimated that fifteen million people died of smallpox in twenty-five years in the eighteenth century, and that sixty million people died during the whole century from that disease. It was brought here from Europe about fifteen years after Columbus discovered America. An authority estimates that six million Indians died as a result out of a population of twelve million. In 1707, Iceland lost 36 per cent of its population from this disease. Its teeth have not been pulled yet in all countries. Russia lost 275,502 in five years from 1893 to 1897. These figures are far more hopeful along bacteriological lines than along sociological ones.

Quite a similar story may be told of the awful disease, hydrophobia. Through the knowledge of the use of an attenuated virus from the spinal cord of the rabbit, Pasteur has given us an efficient method of procedure after possible infection. The results of this treatment at the Pasteur Institute in Paris from 1886 to 1914 range from .94 per cent to .00 per cent of fatalities among the cases treated. There were no deaths in the last 1098 cases. This contrasts favorably with the rate of 6.6 to 10, and sometimes 16.6 per cent among all persons bitten by rabid animals (dogs). A remarkable illustration of preventive methods is found in the case of Great Britain. Beginning with 1887, the muzzling of dogs was made obligatory, with the following results: 217, 160, 312, 129, 79, 38 cases of hydrophobia. Then the muzzling was relaxed out of sympathy for the dogs, and there followed: 1893, 93, 248, 672 cases. Then the law was again enforced. In 1896, 438 cases. Then these: 151, 17, 9, 6, 1, 13; and none from 1903 until 1906, when this record closed.

The part the tonsils have to play in infection is much discussed. Their relation to a form of rheumatism came under my observation in

one case. A prominent man in one of our state institutions was a sufferer from this disease. It had well-nigh caused him to give up his work when he was induced to have his tonsils removed. A rather severe infection of the lacerated surface followed unfortunately, and he suffered another severe attack of rheumatism, worse than ordinary. The infection soon ceased, he recovered at once from the rheumatism, and up until recently during a period of several years, he has not had a single recurrence of his former malady. Other forms of rheumatism respond less favorably.

Many cases of appendicitis are now successfully treated when before our period they were probably unrecognized, or would have been disastrous without antiseptic and aseptic measures.

Diphtheria is of especial interest because of the discovery of diphtheria antitoxin by Behring and Kitasato in 1890. They found that the toxin produced by *Mycobacterium diphtheriæ* provokes the production in the animal body of a substance that will neutralize the free toxin either within or outside of the animal. Its action is not upon the germ but upon the toxin produced by it. Because the horse is found more suitable than other animals for the purpose, it is used for the preparation of diphtheria antitoxin. This is largely because of the large amount of blood that may be withdrawn without serious harm to the animal. At the present it is often purified and concentrated, is then standardized by the use of a government standard unit, tested ærobically and anærobically, including animal reactions for its bacterial purity, placed in the proper receptacles, and is ready for use. It has robbed this dread disease of many of its terrors, and if administered in time (during the first twenty-four hours of the disease) the mortality is practically none. In cases taken as they run in ten states and cities of the United States the fatalities in the decade ending with 1914 ranged from 9.67 per 100 in Michigan to 3.09 per 100 in Newark, N. J. 0.001 cc. of filtered broth culture of this germ has been known to kill a guinea-pig. This is an extreme case, but it illustrates with what man has had to contend in fighting this disease.

Schick has devised a test for the presence or lack of immunity in a person. On injecting one-fiftieth of a minimal lethal dose for a 250 gram guinea-pig into the skin of a person, if there is no local reaction, the person is immune. If there is a white spot at the point of reaction, with a reddened area around it, then there is no antitoxin present in the blood and the person is not immune. Through this test it is quite possible to discover just whom to treat or not in an epidemic. It is supposed to act on the same principle as the tuberculin reaction in tuberculosis.

Among the common diseases of man malaria is one of the most interesting. An historical account of it with the steps taken to come to a definite understanding of its etiology, the modes of its transference, the means of its prevention, etc., reads like a fairy tale. It has long been known. It has probably been one of the causes of the non-development or decay of nations or peoples. Some have thought that Paul's "thorn in the flesh" may have been this disease, contracted in the

marshy districts of Asia Minor. It probably accounts for the fear of "night air" so common in our childhood. The transformation of the causal parasite, the peculiar disparity between the hosts, the life-cycle and habits of the mosquito, and the consequent means of prophylaxis are all rather complicated and remarkable. Laveran discovered the parasite in 1880, and Ross startled science by announcing his methods and the method of its transmission in 1895. The seeming fact that but one genus of the mosquito, *Anopheles*, can act as the alternate host with man is a peculiar circumstance. We here see well illustrated the fact that seemingly unrelated data in pure science may prove of the greatest practical value when coupled with other data. Knowing the life history of the mosquito and its connection with the disease, one method of attack is readily seen. As far as possible, prevent the breeding of mosquitoes, keep them away from the sick and from the well. This mosquito breeds in ponds, or quiet water. Its larvæ breathe through spiracles. Oil will form a thin film upon water. Then drain pools, oil the pools not drainable, screen the barrels. These lessen the numbers of mosquitoes. Screen the home with a fine-mesh netting. Be especially mindful of the sick. Let people stay within doors, particularly at night. This tends to lessen the infection of the insect and also of man. Then it has also been discovered that quinine is a specific in malaria. Take it in proper doses during the dangerous seasons. Some very dangerous localities have been much improved by these practices.

Yellow fever is quite similar to malaria in many ways. It is, however, much more fatal, but fortunately also more limited in its habitat. But one mosquito, *Stegomyia calopus*, can carry the infection, another fortunate circumstance. A person infected cannot infect the mosquito after the third day of the fever, nor can the mosquito infect people until about the twelfth day after drinking infected blood. Most of the above-mentioned facts were learned through the work of four medical officers of the United States army (1900-1902). Of these Lazear lost his life in submitting to experiment, but thereby proved his point. This is another illustration of the cost of some bacteriological facts now of such helpfulness to mankind. In this instance we again see a fine illustration of the extreme practicability of the seemingly impractical pure sciences. I have read that when the Panama railroad was built a life was sacrificed to disease, at that time unpreventable, for every tie laid, a fearful price to pay to ignorance. General Gorgas, having the knowledge necessary, built the Panama canal with but little loss of life from infectious or other disease. The story of this and other triumphs of modern science should be pasted in the hat of every legislator. Knowledge is power! We wish to stop here to voice the prayer that sociology might keep pace with science.

The cause of "sleeping sickness," *Trypanosoma gambiense*, was discovered by Dutton in 1901. Its causal relation was shown by Castellane in 1903. Between 400,000 and 500,000 deaths resulted from this disease in the Congo region alone between 1896 and 1906. The parasite is transmitted to man by a fly, *Glossina palpalis*. According to Rosenau, few, if any, cases ever recover. Jordan says that it is invariably fatal

to man. Ehrlich worked hard to conquer it and did produce a drug, atoxyl, which gave some hope of success. Some of the trypanosomes became immune to the drug, however, and so the purpose of the treatment is thwarted. The most hope at present seems to lie in preventive measures such as isolation of the sick. The outlook on the whole seems discouraging. We are all familiar with recent developments in the bubonic plague. It has come too close for comfort, being fairly well established in California. We know too of the rat-proofing of New Orleans, and of the amount of work and heavy expense incident to such a heroic measure. It is well to bestir ourselves. The "black death" claimed twenty-five million people in 1348-1349. From 1898 to 1907 it caused about six million deaths in British India. We all probably remember the epidemic of the pneumonic type of this disease in Manchuria in 1910 and 1911. The mortality there was over 90 per cent. The transmission of the ordinary type by the flea, aided by rats, was demonstrated early in the century, 1906 and on. Again one of our number, Professor Barber, is quoted as an authority in a report made while he was in the Philippines (Tropical Medicine, 1913, VIII, 241). Through preventive measures such as the destruction of rodents, etc., and the use of Haffkine's prophylactic, there is a possibility of control. Haffkine's treatment is estimated to reduce the chances of infection four-fifths and increase the chances of recovery two and one-half times.

Again we are probably very familiar with tuberculosis, the great white plague, its occurrence, effects, treatment, etc. We may not know that the deaths from it in Massachusetts declined from 500 per 100,000 in 1855 to about 210 in 1906. The tubercle germ was discovered in 1882 and much work has been done with it since, especially by Robert Koch. The germ has been demonstrated in nearly every organ of the body. It is fairly certain that most people are, or have at some time been, infected. From this we see that methods of attacking it should be largely the building up of the resisting powers of the body and thus prevent its encroachment upon the unaffected tissue. Early diagnosis also helps. Sanatoria, where the sick may receive proper treatment while uninfected dependents are cared for at home, are being erected by some states and other institutions. The state can well afford this if any appreciable amelioration results. It is estimated that tuberculosis costs the United States from 150 million to 200 million dollars annually in money. In 1900 it caused about one-ninth of all deaths. Infection by man from the bovine type is supposed to be higher in children and nearly negligible in adults.

Leprosy has, like tuberculosis, been long known among men. It was quite prevalent in Bible times. The present situation is quite hopeful. Treatment is limited largely to isolation and betterment of living conditions about as in tuberculosis. Cures are probably rare. By mild rules of segregation Norway has reduced the number of cases from 2,870 in 1856 to 577 in 1900. Like many other diseases it can probably be readily stamped out through the application of known principles of procedure.

The great mortality among infants during the hotter months has long been noted. Much has been done to lessen this through the ob-

servance of bacteriological principles. Attention to the source and care, and especially the prevention of contamination of the food and drink of the child, have been some of the main measures. The partial elimination of the house fly is a probable factor.

But to limit this address we shall next consider as briefly as we well can the part this science has had in the present world catastrophe. It is indeed an ill wind that blows no good. The desperate need of protective and curative bacteriological practices; the large number of the world's best bacteriologists and other scientists who have turned their greatest efforts along these lines, and the vast amount of clinical material upon which to practice, have resulted in great advances that shall prove blessings of the highest order to mankind for many years to come.

The definite cause of typhus fever has probably been isolated and a severe epidemic in Serbia was put down by Dr. Strong and his helpers. This is a bright page in the war. Cerebrospinal fever, or meningitis, has been largely mastered through treatment, and through prevention, by the discovery of and isolation of carriers. The struggle with pneumonia has not been as encouraging, although the situation is fairly well in hand in the army cantonments. Trench fever has appeared. It is never fatal, but is very painful and lowers the efficiency of the troops considerably. But little other than the symptoms is known about it. The cause seems to be in the red blood corpuscles, but no germ has been reported at this writing. There is much speculation as to its origin. It has probably been introduced by some of the soldiers from the widely scattered regions from which troops have come. It is presumed that lice have something to do in its transmission from the sick to the well.

Gonorrhea and syphilis have received a great amount of attention both in this country and abroad. Serious conditions have been reported both in our cantonments and at the various fighting fronts. The peril to future generations is great unless some radical improvement in conditions is brought about. Conditions in France have been aggravated by the fact that large numbers of women have been rendered dependent by the exigencies of the war. American soldiers abroad are particularly endangered through the fact that they receive by far the largest pay of any of the soldiers fighting there. A startling announcement was made from Philadelphia recently. Dr. Simon Flexner claims to have found a new cure for syphilis, "A, 189," an improvement over salvarsan. It is reported to cost six cents per dose, while the latter is quoted at three dollars for a similar amount. At the same time Dr. Mentzler, also of the Rockefeller Institute, announced a new cure for tetanus. It contains magnesium sulphate. The number of cases of lockjaw have already been greatly reduced, that is, from thirty-two per thousand of wounded to two or less per thousand. This has been brought about through the protective inoculation of every wounded soldier with tetanus antitoxin as soon as possible ofter receiving the wound. This does not shed any light on the magnesium sulphate method. I found no data upon it. "Gas gangrene" from *B. welchii* has been very prevalent and

dangerous. This follows from the fighting in the mud and wound contamination from the infected soil. The bombing of the allies' hospitals by the Germans apparently had this largely in mind, as wounds are much more serious, especially from this infection, if not given attention within a few hours. Curative measures have been devised, but their success is not yet determined.

Infectious jaundice has been abundant, especially in Italy. It is presumed to be caused by a Spirochæte, *S. ictero-hæmorrhagiæ.* The Japanese have discovered that this parasite is common in wild rats. The fact that the trenches are badly infested with rats lends color to the above conclusion. Cholera appeared on the eastern front. However, knowing that it is transmitted in food and drink, especially in water, enabled the authorities soon to bring it under control. The results have not been serious, considering this disease. Treatment similar to that of typhoid helped to hold it in check. In former times the story would probably have been very different.

Amœbic dysentery has caused trouble, but has been pretty well controlled by "emetin," and by using sanitary precautions. Bacillary dysentery has been reached practically only by proper sanitation.

Among all of the diseases prevalent in armies, typhoid fever has long been the worst. Its reign, however, has been too autocratic, and it now has gone to join the already large company of the dethroned, the number of which we hope soon to see augmented. In the Franco-Prussian war, sixty per cent of the mortality in the German army was from this alone. In the Boer war the British had 31,000 cases of typhoid and 5,877 deaths. In the Spanish-American war, out of 107,973 men there were 20,738 cases, 1,580 deaths. One case to every five men, nearly. In contrast there were, in 1911, 12,800 men in the camp near San Antonio, Tex., for about four months. These had all been treated with "Typhobacterin." There was but one case, that of a teamster who had not completed his inoculation, and his case was a mild one. One of my pupils was on the ground and was familiar with the situation. There was plenty of chance for infection in the near-by city to which the soldiers had the customary access. In the present war millions have been treated, ninety-seven per cent of the British army. The death rate in the British army among the treated has been 1/65th of that among the untreated. They are now killing three or more birds with one stone by including in the treatment Paratyphoid A, and B, and sometimes the cholera germs. They are thus disposing of all of these mischief-makers at once. What a record this is!

The general subject of wound infection has been a very important one. Great advances have been made in the three or more years of the war. Methods of antisepsis have enabled surgeons to perform startlingly complex but successful operations resulting in the restoration to somewhat normal conditions of the badly disfigured or mutilated. In former years this would not have been possible. Two general methods of wound treatment are practised. Wright uses a strong saline solution or even a salt pack. The object is to increase phagocytosis and may be called a physiological method. Carrel has used continuous irrigation

with a modified hypochlorous solution. The agents used are chosen because of their selective or discriminatory action, harming the germs while not damaging the tissues. This is an antiseptic method. *Chloramin-T* is another substance much used, and still another that is highly praised in *fluvine,* prepared by Ehrlich some years back for use in sleeping sickness. It has cleared up septic cases of months' duration in a few days. And the end is not yet!

To summarize the situation in the war from our point of view we can well use the following clipping copied from the Emporia *Gazette* of December 27, 1917:

"FIGHT GERMANS AND LIVE.

"New York, Dec. 27.—Fritz-fighting adds five years to your life and has its merits in several other ways, according to late Canadian statistics. Here are some of the chances your boy will take if he goes to the front:

"He has twenty-nine chances of coming home to one of being killed.

"He has ninety-eight chances of recovering from a wound to two of dying.

"He has only one chance in 500 of losing a limb.

"He will live five years longer because of the physical training.

"He will be freer from disease in the army than in private life.

"He has better medical care at the front than at home.

"Only ten per cent of the men disabled for further military service have been unfit to resume their former occupations.

"Less men die of disease than in any war in history."

I think that all will agree that much of this is true because of the present situation in bacteriology. Nor would we in any way wish to detract from the honor due other sciences that have aided in this work. However, our science has not been prostitute in any great degree to wrong uses, as may be said of some others. Its services have been entirely beneficent, restorative, constructive. This is as it should be.

In conclusion, we would add that very much more could be said in such a review. We have scarcely mentioned several great phases of the subject. The members of the Academy have largely witnessed the entire development of this great science, and if a single half century can accomplish so much, what may we not look for in the future, and probably the near future at that!

We would close, as we began, by prophesying that the individual, and especially the people who would thrive and succeed in the race of life, must be cognizant of the principles and practices of the science of bacteriology.

BIBLIOGRAPHY.

Davis, Dr. David John: "Bacteriology and the War." The Scientific Monthly, 1917, v. 4, p. 385.

Egbert, Seneca: "A Manual of Hygiene and Sanitation," 6th ed., 1916.

Faulkner & Robb, Translators of "Studies on Fermentation," by Pasteur (876), 1879.

Harrington-Richardson: "A Manual of Practical Hygiene," 5th ed., 1914.

Jordan: "General Bacteriology," 5th ed., 1916.

Paget, S.: "Pasteur and After Pasteur," 1914.

Rosenau, Milton J.: "Preventive Medicine and Hygiene," 3d ed., 1917.

The Kansas City Times: "Find a Cure for Lockjaw," Nov. 21, 1917.

Symposium: Fifty Years of Scientific Development in Kansas.

The Kansas Academy of Science.

W. A. HARSHBARGER.

We are met to-day to celebrate one more of a series of events not uncommon the last few years. It has not been many years since the fiftieth anniversary of the admission of Kansas into the Union was celebrated. Since then one after another of our older institutions of learning has had a similar celebration. To-day the Kansas Academy of Science completes its first half century, and we are met to honor the event. These celebrations forcibly remind us that Kansas is still in her infancy, and has a future instead of a past.

The conditions to-day also strangely remind us of those at the time of the birth of the Academy. In 1868, just after the close of a long, trying war between two sections of our own country, the Academy came into being. To-day it enters its second half century in the midst of a world war. It would seem that the world is having a rebirth. Some of our own members whom we miss to-day have responded to their country's call and are offering their all to make it a rebirth into an environment in which democracy can live and prosper.

The part assigned me in this program might appropriately be called "Locking Backward." It is mine to sketch very briefly the foundation and early history of the organization, and leave to others the special lines of investigation that have been pursued.

In 1867 Prof. J. D. Barker was called to Lincoln college (now Washburn). Observing that there was no scientific association in the state, and that the scientists then at work had no organization to centralize their work, and no uniform method of publication, he at once began to agitate the matter of forming such an organization, but received no encouragement. People were busy with other things, and science received but little attention. Finally he wrote to Professor Mudge, who was heartily in favor of such a society, but feared the time was not ripe, giving as one of his reasons that Professor Winchell had made a similar attempt in Michigan and had failed. Professor Parker visited Professor Mudge during the long vacation of 1867, and after thorough discussion of the matter secured Professor Mudge's promise to go into the movement. Several articles were then published urging the importance of such an organization, and in the *Journal of Education* for March, 1868, Professor Parker published the following notice:

"We, the undersigned, desirous of securing the advantages arising from the association in scientific pursuits, and of giving a more systematic direction to scientific research in our state, do hereby invite all persons in the state interested in natural science to meet at Topeka on the first Tuesday of September next, at 3 p. m., at the College building, for the purpose of organizing a State Natural History Society."

This call was signed by the following seventeen persons: John Fraser, D. H. Robinson, B. F. Mudge, J. A. Banfield, J. S. Hougham, J. D. Parker, R. A. Barker, D. Brockway, G. E. Chapin, J. H. Carruth, R. D. Parker, Jeff. Robinson, Peter McVicar, F. H. Snow, J. S. Whitman, Richard Cordley, J. R. Swallow. The meeting was held at the appointed

time with a very small attendance and the organization effected. The name chosen, Kansas Natural History Society, was adopted from the Illinois Natural History Society, of which Professor Parker had been a member. The following officers were elected: President, B. F. Mudge; vice president, J. S. Whitman; secretary, J. D. Parker; treasurer, F. H. Snow; curator, J. A. Banfield. No papers were read at this meeting. The second meeting was held at Topeka, September 7, 1869, with a very small attendance. The following papers were read:

On the Internal Heat of the Earth. B. F. Mudge.
On Solving the Higher Equations. Edward Cove.
A public lecture on The Moundbuilders was given by J. D. Parker.

The officers of the previous year were reëlected. The attendance at this meeting was so small, the state of the treasury so unsatisfactory, that a general feeling of gloom and doubt as to the existence of the society was very evident. Here, as on so many other occasions, the energy and optimism of Professor Mudge came to the rescue. He urged the members not to despise the day of small things, and to never say fail until they had really failed. The society was unanimously invited by the three professors of the state university to hold the next meeting in Lawrence, and the invitation was gladly accepted.

The third meeting was held in the University building at Lawrence, September 5 and 6, 1870. This meeting proved to be the turning point in the life of the society. The following papers were read:

On the Plants of Kansas. J. H. Carruth.
On the Fishes of the Kansas River, as Observed at Lawrence. F. H. Snow.
On the Internal Heat of the Earth. J. D. Parker.
On the Comparison of the Coals of Kansas with Other Western Coals. W. H. Saunders.
On the Saurian Formation of Kansas. B. F. Mudge.
On the Moss Agate Formation of Kansas. B. F. Mudge.

The following public lectures were delivered:

On Aims, Organization and Advantage of Scientific Associations. John Fraser.
On Hugh Miller, or the Workingman's Education. J. H. Burrows.

At this meeting resolutions were presented urging the enlargement of the scope of the society so as to include every line of scientific exploration and investigation, and to change its name to the Kansas Academy of Science. These resolutions were adopted at the fourth annual meeting held at Leavenworth, October 25 and 26, 1871. Beginning with the third meeting, the progress of the society was rapid, as is shown by the number of papers read, and their character.

At the meeting of the legislature in 1873 the Academy was made a coördinate branch of the State Board of Agriculture, and given permission to have its proceedings published by the state printer, and also given quarters in the capitol building. This unsolicited act was a well-merited recognition of the work the Academy was undertaking.

Thus far I have followed the reports of the Society literally in an endeavor to show the meagre beginnings, the difficulties and discouragements of the organization. The development of the state has been so

rapid that it is very difficult to appreciate the conditions fifty years ago. The war of the rebellion was just over. The effects of the border strife were still shown in the rifle pits along the south side of the town and the palisades still standing at Kansas avenue and Sixth street. The Union Pacific railway had reached Topeka only two years earlier, and the construction of the Atchison, Topeka & Santa Fe railway was begun that year (1868). The Indians were still on the rampage in much of the state, making travel at times exceedingly hazardous. The famous battle of the Arickaree was fought in the same month in which the Society was organized, and Sheridan's winter campaign in which the nineteenth Kansas participated, and which broke the strength of the plain's tribes, occurred the following winter. Small wonder that the advance of scientific investigation was slow, and that people expressed small interest in such work. The people generally were fully occupied earning the necessities of life. So we find a very small band of investigators on the 82,000 square miles that was the foundation of a great state yet to be, but not yet arrived. This area was covered with a vegetation largely unknown, an unknown population of birds, mammals, fishes, reptiles and insects, while the mineral resources were but a guess. Clearly the first work needed was an inventory, and it was along this line that the members proceeded. It is true that some work had been done, but the condition of the scientific knowledge of the state is vividly portrayed in an article in the *Journal of Education* a little previous to this time, in which the importance of a geological survey was urged. This article advanced the argument that if such a survey only succeeded in discovering coal and salt, it would richly repay the cost.

With this hasty view of the condition of the state at the time of the organization of the Academy, it is my purpose to show from the Transactions how the Academy has made definite contributions to the much needed scientific knowledge. I find myself embarrassed with a wealth of material. It will be impossible to do justice to the individual workers. I can only mention the names of those most prominent in the few lines I shall here record.

From the beginning of its existence, probably the most cherished ambition of the Academy was the securing of an adequate geological survey of the state. The mineral resources were practically unknown, and much money was being wasted in ventures that with fuller knowledge would have been successful, or else would not have been attempted. Hardly a meeting passed without some discussion of this topic. At the seventh meeting Professor Mudge read a very earnest paper on "The Importance of a Geological Survey of the State." At the eighth meeting, a committee was appointed to draft resolutions urging such a survey, and at the ninth meeting these resolutions were adopted. At the sixteenth meeting, in the address of the retiring president, Doctor Thompson spoke very earnestly in favor of such a survey. At the seventeenth meeting Dr. R. J. Brown chose for the subject of the president's address, "Is a Geological Survey of the State a Necessity?" Doctor Brown corresponded with officials in each state where such a survey had been made, or was in progress, and thus accumulated a formidable array of evidence in favor of such a sur-

vey. Without going further into details, it is sufficient to say that after many years of urging and educational work on the part of the Academy, an adequate geological survey of the state was ordered, and the dearest ideal of the Academy triumphed.

But before the survey was ordered, and during its progress, our Transactions are exceedingly rich in papers on geology in its every phase. The first paper read before the Society was a geological paper by Professor Mudge, and at each succeeding meeting up to and including the twelfth, which was the last meeting previous to his death, he read from one to four papers on geological subjects, or twenty-four papers in all. One of these was a list of Kansas minerals, the beginning of a catalogue. Professor Mudge's record is also unique in that during his entire membership he was either president or vice president continuously, and did not miss a meeting. At the fifth meeting Wm. H. Saunders presented his first paper on the analysis of coals and limestones, and followed this with other papers on analysis of coals and clays, thus giving a very practical bearing to the work. Throughout our forty-seven years of existence geological papers have formed an important part of our programs. It is difficult to pass over this part of our work without extended notice of the work of such men as Williston, Hay, Haworth, Cragin, Prosser, Grimsley, Beede, Gould, Wooster, and many others. Our Transactions contain carefully prepared lists of invertebrate and vertebrate fossils, fossil plants and leaves, lists of minerals, with many valuable papers on every branch of the subject, both economic and scientific.

At the third meeting Prof. J. H. Carruth read a paper on the "Plants of Kansas," in which he dwelt largely upon species common in the western states that were not found here at all. At the fourth and fifth meetings he presented papers in which a beginning was made in the identification of Kansas species. At the sixth meeting he presented a preliminary catalogue of the plants of the state. To this catalogue he made additions each year, except 1877 and 1881, until 1889, when, so far as I can learn, his last paper was presented. Professor Carruth was assisted by many local collectors, the Academy furnishing the unifying means. In 1881 B. B. Smyth began an extensive series of contributions, particularly of the plants of the western portion of the state, which was continued until quite recent times. In 1884 Professor Kellerman presented a preliminary catalogue of the parasitic fungi of the state, with their host plants. In 1888 and 1890 Professor Swingle presented a list of Kansas species of Perosporaceæ. In 1894 Miss Reed presented an "Analytic Key to Kansas Mosses," with a list of the known species, and to this she made subsequent additions. Also, in 1894, Professor Hitchcock presented a list of the grasses of Kansas. In 1910 B. B. Smyth and L. C. R. Smyth presented the first part of a revised "Catalogue of the Plants of Kansas," and in 1912 Mrs. L. C. R. Smyth presented the second part, thus bringing the work up to date. This is a bare outline of the systematic work done in botany. There were many other contributors. However, I have given enough to show that through the Kansas Academy of Science as a unifying means the state has been given a fairly exhaustive catalogue of the different forms of vegetable life, and that our Transactions furnish

the record of this work carried on for about forty years. Our Transactions show, also, much work of a more special character, and also work of a general educational nature. The following titles illustrate this class of work:

Black Rot of the Grape. Carpenter, 1887.
Blackberry Branch Knot. Kellerman, 1890.
Sorghum Smuts. Kellerman, 1891.
Characteristics of the Sand Hill Flora. Carleton, 1889.
Kansas Forest Trees Identified by their Leaves and Fruit. Kellerman, 1886.
Artificial Key to Kansas Grasses. Kellerman, 1888.
Evolution of Leaves. Mrs. Kellerman, 1890.

At the fourth meeting Professor Snow presented his first list of the birds of Kansas, to which he made many later additions. Colonel Goss, Professor Lantz and others also contributed to this list, the contributions by Colonel Goss being very extensive. So we have in our Transactions, not only a very complete list of the birds of the state, but an extensive series of valuable papers on their habits and economic importance. The work of Professors Snow and Dyche, and Colonel Goss, is particularly worthy of note in that it has resulted in two splendid collections of mounted birds, the one in the museum of the State University, and the other donated to the state.

At the sixth meeting Professor Snow presented a preliminary list of the Lepidoptera of Kansas, and added to it from year to year, until it is a practically complete catalogue of the Lepidoptera of Kansas.

At the seventh meeting Professor Popenoe presented a preliminary list of the Coleoptera of Kansas, and this has received extensive additions by Professor Snow, Mr. Knaus and others, and as our program shows, is still in progress.

Professor Popenoe published a preliminary list of Kansas Hemiptera in 1884 and a list of Hymenoptera in 1885, both of which have received large additions.

Other lists published in our proceedings are:

Catalogue of Kansas Mammals. Knox.
Catalogue of Kansas Fishes. Graham.

Also, lists of serpents, clams, Orthoptera, and Diptera, which I pass for want of time. Surely this work of classification alone would justify the existence of the Academy, and these published lists render the proceedings very valuable. Yet this is only one of a large number of lines of investigations carried on.

In meteorology the summaries published by Professor Snow formed for years the only available records on Kansas weather. This line of work was also taken up by Professor Lovewell, at Topeka, and finally culminated in the establishment of a station of the U. S. Weather Bureau.

In chemistry, that many-sided subject, our Transactions are particularly rich. Beginning with the work of Professor Saunders in the fifth and seventh meetings, in which he presented analyses of coals, limestones and various clays, the chemists of the Academy have kept in close touch with the development of every branch of the subject, and nearly every

volume of our Transactions contains valuable papers that touch our industrial development at its every point. The names of Kedzie, Patrick, Failyer, Bailey, Sayre, Willard, Franklin, Bartol, Cady, Dains, and many others are very prominent and deserve extended notice. Beginning with his paper in 1883, on the utilization of mineral waters, Professor Bailey has presented about fifty papers, on food products, water supply, oils, and so on, but notably on foods. While beginning with Professor Sayre's paper on "Loco Weed," in 1886, he has presented about the same number, for the most part of the chemistry of drugs, spices, tea and coffee. The work of Professors Failyer and Willard is devoted largely to agricultural chemistry, in which line they have presented many papers.

In physics and engineering, our Transactions, beginning with the fifth meeting, contain a series of valuable papers by Tweeddale, Nichols, Blake, Smith, Marvin, Hoad, Murphy, and many others, on a wide variety of subjects, from the theoretical to the most severely practical. Such titles as the following illustrate the character of this work:

On Ventilation. Tweeddale, 1872.
The Water Supply of Kansas. Tweeddale, 1874.
Statistics on Color-blindness in the University of Kansas. Nichols, 1884.
Tests of Cement Manufactured in Kansas. Murphy, 1889.
Magnetic Declination in Kansas. Marvin, 1889.
Maximum Bending Moments for Moving Loads in a Draw Beam. Murphy, 1892.
Tests of the Strength of Building Stones. Marvin, 1893.
Collection and Storage of Water in Kansas. Murphy, 1894.
Water Supply from a Sanitary Standpoint. Marvin, 1901.
Effect of Clay and Loam on Portland Cement. Hoad, 1904.
On Improved Water Supply for the City of Emporia. Smith, 1910.

Finally, in the forty-seven years of its existence the Academy has accumulated a library of at least six thousand bound volumes, and fully as many pamphlets. These represent the work of scientific investigators in all the leading countries, as well as our own, and form a very valuable addition to libraries of the state. This library has been secured almost entirely by exchange for the Transactions of the Academy.

I have thus sketched the growth and work of the Academy in an endeavor to emphasize the fact that from the beginning, when the state was new, and scientific knowledge of its resources, of the composition of its plant and animal life, was sadly needed, the members have attacked the problems at hand and carried them through the succeeding years, accumulating and recording knowledge of priceless value to the state. Much of the work has been classification, taking an inventory, as it were, but such work is imperative. I have also attempted to show that the Kansas Academy of Science has been the means of unifying the work of the investigators, a central organization from which radiated the varied lines of investigation, and that in our Transactions we have in a body records that, without some such clearing house, would be widely scattered, and probably many of them lost. Also, without the stimulus of some such organization many of the records of work would never have been published. Having thus reviewed the past, let us turn to the future. Has the need for such an organization ceased? The character

of the work has indeed changed, but there exists even a greater need of scientific investigation, and in many more lines than in the early days of the state, and this need will increase as our civilization becomes more complex. We now have state boards, commissions, etc., that make their reports through different channels, but in each of these there are questions without number of a purely scientific character, that find no place in such reports. Such questions should continue to be worked out in our meetings and the results published in our Transactions. The work in botany has changed to the search for or breeding up of plants better adapted to our economic needs, and to combatting injurious parasitic forms. The immediate, usable results of such work would of course be given to the people in bulletins, but the scientific investigations should not be lost. These should find a place in our transactions. In the most ordinary experiment in plant breeding, even one that produces no commercial result of value, often some exceedingly important new facts in heredity are brought to light that should be given publicity. Then there are numberless new developments just ahead of us. What thoughtful person who considers the development in the cement industry, with its almost revolutionary effect on engineering and architectural construction, will dare to say that we have reached the limit of our mineral resources? Yet this is a thing of the present, undreamed of when the Academy was organized. Our clays have only begun to yield their wealth, and in every line we are merely at the beginning of our development of mineral resources. In engineering there is an immense field opening. We, in Topeka, are still buying ten-cent electricity, while the Kansas river is carrying by each day enough of the same article, at two cents, to supply our every need and add greatly to the comfort of living. Irrigation, conservation and control of flood waters, are also problems of the immediate future. There is no lack of room for work for such an organization; indeed, the amount and variety of work pushing to the front is so great as to be almost bewildering. It is clear to me that the Kansas Academy of Science has a greater opportunity to do beneficial work for the state now than it has ever before had, and this opportunity will increase with the years. If the Academy in its new environment can demonstrate its ability and willingness to do this work efficiently and can devise some plan for prompt publication, there need be no question of its success during its second fifty years.

Washburn College, Topeka.

Botany in Kansas During the Past Fifty Years.

LYMAN C. WOOSTER.

The collecting naturalists of the nineteenth century made the science of botany possible during the twentieth. It was a labor of love on their part, for the enthusiasm engendered by the discovery of new species of plants has sent many a botanist through swamps, deserts and over mountains in the search for specimens. Gray, Torrey, Wood and a hundred other pioneers in this fascinating field of work listed the plants of Europe, America and other continents and published the descriptions of the

species in dozens of manuals of botany for the use of students and other naturalists.

The reports of this Academy of Science show in nearly every volume that the botanists of Kansas were deeply interested in doing their part in the work of cataloging the plants of the state.

In volumes I, II, III, V and VII, Prof. J. H. Carruth catalogs 1,437 species, of which 71 were not found east of the Mississippi river. Among those who assisted Professor Carruth in this work were Professors Snow, Hall, Popenoe and several others. In volume VIII, Professor Carruth increases the number of species of plants higher than the mosses in Kansas to 1,473.

The interest aroused in plants through the making of a complete list of the plants of the state, and the description of new species, very naturally led to an interest in the life history of the plants collected. This in turn caused the botanists to place increasing emphasis on the medicinal, textile and food value of plants to man.

In volume X, Prof. and Mrs. W. A. Kellerman furnish an excellent key to the forest trees of Kansas based on the leaves and fruit, and in volume XI, Professor Kellerman gives a key to the Kansas grasses. In the same volume, Prof. W. T. Swingle gives a list of the parasitic fungi of Kansas together with the names of their host plants. In volume XII, Professor Swingle makes corrections to his list of parasitic fungi, and B. B. Smyth corrects Professor Carruth's list and adds some five hundred new names. The revised list contains 1,666 flowering plants, 40 ferns and filicoid plants and 96 mosses. In volume XIII, B. B. Smyth increased these numbers to 1,790 flowering plants, 40 ferns and filicoid plants, 108 mosses, 3 algæ, 7 sapropytic fungi, 1 liverwort and 8 parasitic fungi. To the last must be added 458 parasitic fungi listed in various volumes by Professors Kellerman, Carleton and Swingle. In 1910 and 1912, B. B. Smyth and his wife, Mrs. L. C. R. Smyth, presented to the Academy their completed lists of the plants of Kansas. These await publication, excepting the part listing the sporophytes. Two very important papers on plants were published in volume XIV. One by Prof. A. S. Hitchcock listed the grasses of Kansas, and one by Miss Minnie Reed described with illustrations the mosses of Kansas and furnished a key for their identification. With the presentation of these lists of plants to the Academy the period of intense activity by an enthusiastic band of naturalists came to a close. They did their work well, and their untiring zeal in cataloging the flora of Kansas made the science of botany for our state possible.

While the work of studying and listing the flora of a state is intensely interesting to naturalists, it proved to be just the reverse to the pupils in the public schools and colleges. The naturalists invented and used three hundred and fifty descriptive terms. These were truly Greek and Latin to the boys and girls and they rebelled at the task of learning and applying them. The attempt to force morphological botany on the schools has resulted in failure, and the pupils and teachers were right, for morphological botany has as little juice in it as a sucked orange, and it has by itself almost no educational value.

But studies of the external and internal anatomy of plants worth knowing, of the functions of their important parts, of plant habits and plant diseases, taken in connection with studies of plant embryology and plant development, are all intensely interesting to pupils and teachers. By plants worth knowing is meant those plants that have informational, æsthetic, industrial, medicinal or food value. The older botanists paid little attention to the usefulness of plants to people, but were content when they had described the parts of a plant, had found its name and had noted its habitat.

The new botany received increasing attention in the later volumes of our Transactions. In volume XVIII, B. B. Smyth describes 307 plants, giving their medicinal values. In volumes X to XXVII, Prof. L. E. Sayre contributed many papers on plants, giving chiefly their medicinal values. Prof. J. T. Willard and others of the Agricultural College have presented papers at nearly every meeting in recent years on crops and their feeding value.

It would be impossible to give in this brief summary of papers on botany even a brief description of other papers read by members of the Academy, but the titles of a few of them will show their trend: "The Native Plants of Kansas Adapted to Cultivation," by Grace R. Meeker; "The Rusts of Kansas," by Elam Bartholomew (154 species and their hosts, volume XVI); "The Development of Our Knowledge of Bacteria During the Past Fifty Years," by Frank U. G. Agrelius, retiring president of the Academy; "The Scientist on the Farm, and Origin and Development of Plant and Animal Instincts," by L. C. Wooster; and numerous references in papers and addresses to plant evolution, plant pests, plants for ornamentation and shade, plant tissues in the arts, and plants as manufacturers of foods for animals, including man.

Formal studies in the schools and colleges are rapidly giving way to studies with valuable content, content that will function in the after experiences of the boys and girls. This statement is based on statistics gathered by the U. S. Department of Education and on reports of the discussions at the meetings of the National Education Association. According to these statistics and reports, the number of pupils in high schools studying formal botany, formal zoölogy, formal physiology, formal geography, Latin, algebra and astronomy, is at the present time rapidly decreasing. Colleges throughout the West, at least, are modifying their curricula to meet the present needs of their constituents. Ex-president Charles W. Elliott investigated seventy-five colleges and universities and found that forty-five of them required no Latin for graduation with the degree of Bachelor of Arts. All this means that general culture in science, mathematics and ancient languages is on the wane, and specific culture to meet the actual needs of people is in the ascendency.

Kansas State Normal School, Emporia.

The Progress of Chemistry in Kansas During the Last Fifty Years.

E. H. S. Bailey.

Looking at the immense advance made in the field of chemistry, it is interesting to notice some of the contributions to this science in Kansas, and especially what has been done in the fifty years of the life of the Academy.

Kansas was and is preëminently an agricultural state, and for years little was done in applied chemistry. To the colleges, such as the University of Kansas, the State Agricultural College, Emporia Normal, Washburn, Baker, Southwestern, Ottawa, McPherson and others, and to the larger high schools, was left most of the work of instructing in chemistry. All these institutions at a very early period in their history offered elementary courses in chemistry, which were soon extended to include qualitative and quantitative analysis. In the more recent years organic chemistry and physical chemistry, as well as many special courses, have been added to the curriculum in these schools.

The instruction given in the various schools led to sending out a large number of scientific men and women, who have made their mark in chemistry and allied subjects. Many well-equipped men have been sent to the various departments of the national government and to state experiment stations.

In addition to the work of instructing in chemistry, these institutions have found time to carry on research work. As an illustration, note the extent to which the Transactions of the Academy of Science has been used as a means of publication of papers on chemistry. The first chemistry paper was by W. H. Saunders, the first professor of chemistry in the University, on the "Comparison of Kansas Coals with Other Western Coals." Up to the year 1900 chemical papers were published as follows: By E. H. S. Bailey, twenty-five; L. E. Sayre, sixteen; J. T. Willard, eleven; G. H. Failyer, eleven; George E. Patrick, eight. That is, a total of about eighty papers of an essentially chemical nature were contributed during this period by the above men and others associated with them. That these papers had a very practical bearing on the economic development of the state is apparent from a glance at some of the titles, such as "Kansas Chalk," "The Iola Gas Well," "The Waconda Meteorite," "Ozone in Kansas Atmosphere," "Ammonia and Nitric Acid in Rain Waters Collected at Agricultural College," "Some Kansas Mineral Waters," "Chemical Composition of Kansas Coals," "The Newly Discovered Salt Beds in Ellsworth County," "Chemical Composition of Cement Plaster," "Effect of Continuous Cropping of Wheat on the Composition of the Soil," "The Sugars of Watermelons," "Variations in the Nitrogen Content of Maize and Possibilities for its Improvement."

There is no necessity for going into details regarding advancement in chemistry during the last few years, since most of those present are familiar in a general way with the progress that has been made. However, it would not do to let the opportunity pass without calling atten-

tion to the great usefulness of chemists in connection with the present World War. In this work, it is needless to say, the Kansas chemists have done their share.

No résumé of the chemical work would be complete without reference to the Trego county coal shales, which were exploited many years ago; and while some of our citizens invested in land, to their sorrow, the assays made at the University laboratory showed that the shales were worthless. In connection with the Iola mineral water, it is interesting to remember that this well was bored in 1873 to a depth of seven hundred and twenty feet, and water and gas were forced up. At this depth the drilling was stopped, yet within a few hundred rods of this well, many years after, the prospectors drilled a well to the depth of eight hundred to nine hundred feet and obtained an abundance of natural gas, which helped to make Iola an important manufacturing center. The drillers stopped just short of a great discovery. The water coming from the well was analyzed by Professor Kedzie of Manhattan and by Professor Patrick of the University, and was used locally and shipped for a score of years.

By being on the ground immediately after the discovery of the Kiowa county meteorite, Dr. F. H. Snow secured a number of very valuable specimens. These were analyzed in the chemical laboratory at the University, and many of them were afterwards sold to eastern dealers. Some of the best specimens of the Washington county meteorite were also obtained by Doctor Snow and analyzed here.

The Federal Government experimented with the use of sorghum for making sugar in the early eighties, under the direction of Dr. H. W. Wiley, of the Department of Agriculture. Mills were erected for making sugar from sorghum at Medicine Lodge, Topeka, Ottawa, and Fort Scott. The factory for making syrup at Fort Scott is the only one that remains.

Many of the contributions to chemistry noted have been along lines for the development of the industrial resources of the state. A great impetus to this branch of chemistry was afforded by the establishment of the Department of Chemical Industrial Research, under the late Dr. R. K. Duncan, and many of our successful chemists, graduating in the chemical course, afterward took up lines of investigation, both here and at Pittsburgh, Pa., under that foundation.

Another school for the education of chemists after they had been started in the colleges was the chemical laboratory of the Santa Fe railroad at Topeka, and many of our men are still in the employ of that corporation. The zinc and lead mining industries in the southeastern part of the state have absorbed quite a number of men who have since become superintendents of the plants where they entered as chemists. More recently the gas and oil interests are affording opportunities for chemists, as well as geologists, to add their practical contributions to the sum of scientific knowledge.

The smelters, oil refineries, soap factories, and packing houses of Kansas City, St. Joseph and Omaha have taken many of our chemists, and have begun the training of young men who have afterward come to us for a complete course in chemistry.

We all recognize the importance of the science of chemistry to the geologist, the botanist, the physicist or mineralogist, as well as to the physician and the student in home economics. It is only by the study of chemistry alongside of these other sciences that the students have gone into the world with a fully rounded knowledge of their special subjects.

What has chemistry wrought in the last fifty years? It has assisted in transforming a treeless plain into a garden of luxurious abundance. It has been the handmaid of the farmer, of the miner, of the dairyman, of the horticulturist and the manufacturer in developing the latent resources of the state of Kansas.

The Early History of Medicine.

J. M. McWharf.

In the brief time allotted a paper of this character, I can but touch some of the high points. Medicine is one of the most noble of all arts, but through ignorance on the part of many who enter this field it is to-day far behind all other arts. Physicians are many in title, but few in reality. A student of medicine must bring love to the task of labor and perseverance, so that instructions received may take root and bring forth proper and abundant fruits. He must have a true knowledge of medicine, that he may become an esteemed physician in name and reality.

The evolution of medicine from its primitive stage to the present moment presents many fascinating and ludicrous sides.

It would be a pleasure to enter in detail upon the subject matter, but time prevents such consideration. Medicine has been divided into three periods or ages. First, the mythological; second, the dogmatical or empirical; third, the rational. The mythological age began with the human race, coming on down through the centuries to 400 years B C. This was followed by the dogmatical or empirical age, which continued to the close of the eighteenth century A. D., with the death of the Brunonian system.

Here the rational system of medicine enters the field, and Hippocrates has the credit of being the father of this system. To-day we look upon the teaching of Hippocrates as rational empricism. Long before the birth of philosophy there appeared an order of priest-physicians, cultured by the Asclepiadea, who traced their origin to a mythical personage known as Esculapius. They created temples of health in which they placed their patients, who on entering the temple must undergo purification, bathing or friction, followed by fomentation with odoriferous herbs. Then came a period of total abstinence of food, followed by permission to eat the flesh of animals that were brought to the temple for sacrifice. Religious ceremonies with music were used. In fact, anything and everything to play upon imagination. The asclepia or hospital was as a rule located near a spring, the water of which possessed medicinal properties. Primeval man was powerless with this medical armament to battle against the ravages of an epidemic like the black death of the fourteenth century, which claimed in China alone thirteen million. The human race for centuries have struggled against influences that were an-

tagonistic to their well being. During these years the healing art was primitive and crude, and for centuries it struggled along under a depressed and deplorable condition. Medical divinities were worshipped by the Greeks and Egyptians, and this system was in vogue as late as Alexander the Great. There were thirty-six of these human gods, each controlling a separate or distinct part of the body. Esculapius was the Greek God of Medicine. He used songs, dances and incantations in the treatment of diseases. One of his principal remedies for internal treatment contained wine, meal and cheese. In the sixth century we find Pithagoras, a pious fraud, with Empericlees and Anaxagoras as followers.

Their knowledge of drugs was crude, vague and indefinite, and their practice of medicine was replete with superstition. Five hundred years before the Christian era, quack nostrums were sold in the cities of Greece. In this sunset splendor of the nineteenth century, with all our boasted intelligence, they are a strong factor with the people. This superstition of the ages clings to our skirts, and through the ages past it has been a strong factor against the advancement of medical science. Anatomy, chemistry and physiology were in fact unborn when Hippocrates entered the field of medicine. There was a force, termed by him Nature, and upon this he relied. His pathology was humoral. Many terms used by him are still retained, as acute, chronic, epidemic, sporatic, benign and malignant.

The dogmatical school of Hippocrates was confronted by a rival known as the empirical. They were strongly antagonistic, and contested for the supremacy. During this contention the field was entered by another sect, known as the methodical. Asclepiades was the founder. He possessed little knowledge of the fundamentals of medicine. Soon followed the pneumatic and eclectic. Galen, A. D. 130, entered the field as an eclectic, but soon became prominent as a dogmatical figure. As a result of his efforts this school came to the forefront for sixteen centuries. He looked upon medicine as an art that taught how to preserve health and cure disease.

He treated fevers inhumanly and barbarously; windows closed, extra covers used, and hot drinks; nothing of a cooling nature permitted.

With Galen's death the dogmatical system of medicine began to decline.

In the early part of the Christian era a strong belief was prevalent that a supernatural power had been transmitted to the elders of the church, whereby disease was cured through the intervention of Providence. This idea of ignorance and superstition predominated down to 1315 A. D. Exalted virtues were also ascribed to medicines that were prepared during the conjunction of Venus and Jupiter. From 415 B C. down to 1800 A. D., the iron hand of ignorance and superstition held sway. At that time the rational age of medicine came into the field, and step by step, slowly but surely, she has advanced to the honorable and exalted position that she now occupies. Prior to the eighteenth century all animal, vegetable and mineral substances had been used in the treatment of diseases. In the animal kingdom were the flesh of lizards,

crocodiles, vipers, brains of wolves, heads of mice, bodies of moles, liver, lungs, blood and organs of generation of animals, etc.

The excrement of animals was used internally and externally. Poultices of mashed spiders were used, and the heart of the hare worn upon the back of the neck for the cure of malarial fevers. Newly born puppies were cooked and eaten to make the individual immune from colic. Such treatment, doubtless, is disgusting to the more fastidious of our day, but were as effective in the cure of diseases as are many of the plasters and pads in use at the present time. "Thoriac," a compound comprised of 150 ingredients, was held in high esteem, and it was retained in the British Pharmacopœia until a little over 125 years ago.

To-day, as in the past, it is difficult to rid the field of medicine of remedies that possess no merit whatever. What are the conditions found in the medical profession at the present time? Rationalism predominates, and, as a rule, medicine is prescribed from a scientific standpoint. The better class of physicians are at work along a line termed the expectant treatment, relying very largely upon nature to accomplish the end desired.

I am looking forward to a time when the expectant treatment will be coupled with laws governed by sanitary science. The physician will then prescribe rules of living and thus prevent diseases, instead of medicine to cure the ills that flesh is heir to. Sanitary laws will become more and more a governing factor in our lives.

A correct system of living is the end to be desired. In the prevention and treatment of diseases our science culminates and becomes an art. If unable to accomplish these ends the world would be as well without as with our aid.

We should be able to ward off or cure disease. Our mission is to cure the curable and comfort the incurable. It is impossible for me at this time to enter into detail, yet it is obvious to an observer that therapeutics has undergone very great and important changes during the last half century. For many diseases the mode of treatment to-day is the opposite of that in use but a few years ago. An explanation of this change is to be found in the idea that previously theory was the ground work of therapeutics. Now, fact is the basis of treatment. In other words, once disease was treated by its name; at the present time known conditions govern its treatment. Local changes were the guide in the past; now, the general condition of the patient is held in high esteem as a therapeutical informant. When pathology was in its infancy, medical practice was an empirical art, and it had all its evils. With the growth of pathology, therapeutics, still an art, is becoming a science, having a better knowledge of the limits of its powers, hence is content to attempt less heroic measures, being convinced that it does less harm. More real good is accomplished with medicine than ever before in its history.

As a rule we have no set theory, but act upon the nature of diseases from a general standpoint. Our knowledge of the laws that govern morbid changes is better than it was during the past history of medicine.

The treatment used is based upon a true appreciation of the general

pathological conditions, regardless of theories, whether they come to us with names hoary with age and ludicrous from their novelty. Day by day the veil of ignorance, superstition and intolerance is being lifted, and the time is near at hand when independent thought and correct reasoning must and will bear sway. Then the practice of medicine will stand upon merit and her own worth. She demands this and nothing more.

Ottawa.

The Early History of Pharmaceutical and Medical Chemistry.

L. E. Sayre.

If any one is inclined to boast of his ancestry, we are told he will be relieved of his self-esteem if he goes back a few generations, when he is sure to find a jail-bird or some sort of a criminal. Pharmacy and medicine alike, by such a process, will be obliged to be somewhat modest, at least if they look up their past history. One need not go back farther than the sixteenth century—the period of medical mysticism, the iatrochemical period—to discover one of our forefathers, Paracelsus by current name. His real name, however, was Phillipus Aurelolus Paracelsus Theophrastus Bombastus von Hohenheim. He was certainly a "bird" if not a jail-bird. One writer says of him: "He lived like a pig, looked like a drover, found his greatest enjoyment in the company of the most dissolute and lowest rabble, and throughout his glorious life was generally drunk." It is true that his life offered a strong contrast to his mentality, but he was a man of noble character and intentions, an ambulatory theosophist, who hoped to inspire mankind with a love of conscientiousness and veracity and to restore the suffering to health. He, bad as he was, liberated chemistry from the yoke of alchemy and joined it with medicine. He was an iatro-chemist, which, being translated from the Greek, signifies physician-chemist. He accomplished this during a period of ecclesiastical and national reformation, when Luther and Calvin were combating against superstition, and the changes he wrought, through his originality of thought and teaching, and freedom and vigor of expression, well entitle him to the appellation some have seen fit to give him, the "Luther of Medicine." So desirous was he of penetrating into the mysteries of nature, however, that he neglected books and took prolonged journeys through most of the known countries of the world (probably distances of about that from Kansas City to Chicago, or less). He sought to glean every scrap of knowledge obtainable from literary and learned men, mechanics, metallurgical workers, occults, and every one with whom he came in contact. He returned to Switzerland about 1525, and was recommended to the chair of physic at Basel. His self-confidence appears at this institution by publicly burning the works of Avicenna and Galen. He at once began his fight against the old medical school. He was forced to leave Basel in 1527, after a quarrel with the municipal council, and withdrew into Alsace, whither his fame in medicine followed him.

Paracelsus taught that "the object of chemistry is not to make gold, but to prepare medicines." He considered that the operations which occur in the human body are chemical ones and that the state of health is dependent upon the composition of the organs and the juices they secrete. Medicine, he asserted, rests upon four pillars, chemistry, philosophy, astronomy, and virtue. Organic (?) bodies were composed of mercury, sulphur and salt, which corresponded to the physical "phenomena of volatilization, combustibility and solidification," but which were related in a higher sense to spirit, soul and body; and the increase and decrease of these principles from their normal amount caused illnesses.

One of the disciples of Paracelsus, Johann Baptist von Helmont, was apparently modest. He says: "I thought it more profitable, seriously and conscientiously, to examine myself; and then I perceived that in reality I knew nothing, or, at least, nothing that was worth knowing. Finding that nothing was sound, nothing true, and unwilling to be declared master of the seven arts, my conscience told me I knew not one. The Jesuits, who then taught philosophy at Louvain, expounded to me the disquisitions and secrets of magic, but these were empty and unprofitable conceits; and instead of grain, I reaped stubble. In moral philosophy, when I expected to grasp the quintessence of truth, the empty and swollen bubble snapped in my hands. I then turned my thoughts to medicine, and having seriously read Galen and Hippocrates, noted all that seemed certain and incontrovertible; but was dismayed upon revising my notes, when I found that the pains I had bestowed, and the years I had spent, were altogether fruitless; but I learned at least the emptiness of books and formal discourses and promises of the schools. I went abroad and there I found the same sluggishness in study, the same blind obedience to the doctrines of their forefathers, the same deep-rooted ignorance." He therefore concluded that medical knowledge was not to be obtained from the writings of men or from human industry.

One of his discoveries was that dirty linen packed in a vessel with flour would in time produce mice, and that a toad's bones applied to an offending part was a certain anodyne. He boasted that he possessed a fluid, the "alcahest," which was capable of penetrating into bodies, producing an entire separation and transmutation of their component parts. No one, not even his son, saw this wonderful fluid, and its possession was a secret von Helmont cautiously guarded.

Von Helmont looked upon water as the chief constituent of all matter, and brought forward many arguments in support of his theory from the animal and vegetable world. That water was present in organic bodies he concluded from the fact of invariably procuring it as a product of their combustion. He believed that he contributed a strong proof of this by the following experiment: He took an earthen vessel of large dimensions, and filled it with two hundred pounds of dry earth, in which he planted a willow weighing five pounds. This was then duly watered with rain and distilled water for five years, at the end of which time he pulled up the willow and found that it weighed one hundred and sixty-nine pounds and three ounces. Moreover, the earth had decreased two ounces

in weight. He therefore concluded that one hundred and sixty-four pounds of root, leaves, etc., had been produced from water alone, and that it was the only nutriment of plants. Fish, he asserted, live on water, and nevertheless, they contain all the peculiar animal substances; the latter are therefore produced from water. Basing his belief on such imaginary proofs as these, von Helmont was convinced of the transformation of water into earthy matter. With respect to his views concerning the four Aristotelian elements, he denied altogether that fire could be of material nature, but it is uncertain whether he regarded air as an element or not. His conception of the elements also differed from those of Basil Valentine and Paracelsus, for mercury, sulphur and salt were not to be detected in the human body.

The iatro-chemical doctrines contributed much to the general advancement of the science of chemistry, but two mistakes were made by the iatro-chemists; they endeavored to explain, on chemical principles, all the changes and processes occurring in the body, an attempt which was futile for the chemistry of that day; and, secondly, they set too narrow a limit for chemistry, which was not destined to remain in a subordinate position. Consequently, their medico-chemical ideas were upset after the middle of the seventeenth century.

Medicine developed very gradually until the time of Galen, who developed the use of vegetable drugs and herbs in pharmacies where at that time medicine was practiced with the administration of such vegetable potions and herbs as were then used.

One of the ancient pharmacists of the fourth century describes a "water of the gods" as Panacee (from Pan and aqua) as a cure-all, and from this is derived our word panacea.

Then in the sixteenth century we pass to the school of medical alchemists, the most famous of whom was Paracelsus. This school was called the iatro-chemical school and its theory announced by Paracelsus was that the healthy body, being made up of certain chemical substances in solution, could, when diseased, be cured only by the same chemical substances; hence he preached that Galen's theory of herbs and vegetable drugs curing the diseased body was erroneous. He hence dosed heavily with mercury salts, blue vitriol, sugar of lead, antimony salts, sulphuric acid, iron salts. While he, and especially many of his pupils, killed many people and were driven out of town after town, his theory gave the next great impetus to pharmacy and, incidentally as well, founded chemistry, for the great problem now became to invent and discover new chemical compounds for the relief of disease, and this was done in the shops of the alchemist-pharmacist. His successors, Sylvius, Tachenius, Von Helmont, Agricola, Glauber, Libavius and Pallissy, in consequence developed a great number of such metallic compounds as well as some organic compounds. Here we hence see that in the early history of all three sciences—medicine, pharmacy and chemistry—all three were practically united in one, and frequently practiced by one person, who, however, almost invariably received his training in a medical school and bore the title doctor. The alchemist's shop was the pharmacy and the owner of it practiced the healing art as well as the preparation and compounding of his medicines. From these

shops developed, through the zest for discovering new medicines, the chemist and the science of chemistry.

Later came the separation of all three during the eighteenth and nineteenth centuries, and gradually the chemist became the scientific student looking for scientific laws governing the composition of matter and the changes it undergoes; the medical men became the curers of disease and the student of the human body in health and disease, while the pharmacist became the student of the plants of the field and forest, the chemicals of the chemist, and their proper preparation in forms suitable for administration as medicines. Each had his field, and each field was important and required great patience, ingenuity and careful study and observation. Each science developed gradually and steadily along different lines, medicine and pharmacy confining their activities to curing disease, while chemistry not only did its share to produce new medical substances, but spread out gradually over all the other branches of industry that have to do with matter of any and every kind, until to-day any industry that does not employ the latest discoveries and methods of chemistry in its processes, from the laundry to the steel plant, cannot successfully compete with its present-day competition.

Such were the remote beginnings of pharmaceutical and medical chemistry. We may imagine one of our remote ancestors brought face to face with disease. How mysterious must have seemed to him the phenomenon that to-day he is strong, active and full of life and to-morrow he is weak, listless and about to die. How earnestly he must have sought for means to remedy it. Spiritual and material means appealed to his untutored mind. The modern savage shows the relics of this dual method of combating disease. On the material side he found, in his search for remedies, activity in bitterness and bitter substances, which he came to regard by experimental method as beneficial. Harry Frank, in his recent fascinating work, "Vagabonding Down the Andes," gives the following interesting story which is apropos. He is describing Loja, which was once the center of commerce in South America in cascarilla (cinchona):

Loja was once the center of the commerce in cascarilla. The bark of a tree not unlike the cherry in appearance abounds in the ravines of the mountains to the eastward of the city. Nearly three centuries ago a missionary through the region found the Indians grinding the bitter bark in their stone mortars and swallowing it as a specific against intermittent fevers, as they do to this day. When the wife of Conde de Chinchon, viceroy of Peru, lay ill of the fever in Lima the corregidor of Loja sent to her physician a parcel of the powdered bark. Upon her return to Europe the Condesa carried a quantity of the magic powder with her, whence it was for a long time known as cinchona. Meantime, Jesuit missionaries of Brazil had sent parcels of it to Rome, whence it was distributed among the brotherhood, nothing loath to add to their reputation for miraculous powers and to the income of their drug store, and the name of "Jesuit bark" became widespread. The tree, however, has always been known to the Indians by the name Quina-Quina, and in time the refined product, quinine, took on its modern name.

From ancient times to later periods a mass of bitter and nauseous substances were found and stored in the medical armory, used in the battle against disease. Now the time was ripe for the pharmaceutical chemist who devoted his energies to the problem of active principles (such as alkaloids, glucosides, resins, etc.) from these simple bitter substances, thus finding out their chemical composition and the relation these had as antagonists to disease. We have then, as a result, the principles well known as quinine, morphine, atropine, aconitine, strychnine, digitalline, cocaine, codein and a host of others, and these have been (with coöperative work with physicians) *classified* with reference to their disease antagonistic properties. So that now we are entering upon the domain of *rational* therapeutics, and pharmaceutical chemistry has come to its own as a distinct science, while medical practice has all it can do to attend to its specialized field, which, like pharmacy, is rapidly becoming divided into groups of specialists that promises for the future greater and greater efficiency.

University of Kansas, Lawrence.

The Progress of Science Since the Foundation of the Kansas Academy of Science.

SAMUEL W. WILLISTON.

It was fifty years ago last autumn that, as a lad, I came under the instruction of the late Prof. B. F. Mudge of the Kansas Agricultural College. Bred as a lawyer in Linn, Mass., his early love for science led him into the study of chemistry, mineralogy and geology. Serving for a while as chemist in an oil refinery in Kentucky, his staunch New England training sent him, like so many others in those days, to Kansas, the border land of freedom, where, after a brief service as state geologist, he was made professor in the new Agricultural College.

It was his lectures on geology in Manhattan that inspired in me, a boy—inspired is the right word—the love for science that has lasted throughout my life. For ten years I was more or less under his guidance and influence, in the school room and in the field. My debt to him has never been, can never be repaid. He taught me all of science that was then taught in highest institution of learning in Kansas—natural philosophy as it was then called, chemistry, geology, botany, mineralogy, zoölogy, veterinary science, surveying and mathematics; and for a while even he was my instructor in Latin. A beloved teacher, a noble and upright man, he loved science for science's sake, without regard for personal emolument. He was the real founder of this Academy; nay more, the founder of science in the young state of Kansas, and as such his name will never be forgotten in its annals.

I recall vividly the beginnings of this Academy and the part that he took in its foundation. I wonder if there are others who do? And I recall the talk he gave his pupils about it and what he hoped for its future. I would that I could tell him how grandly his hopes have been fulfilled. The Academy has had an honorable past; may its future still be as bright as he foresaw.

It is then fitting in this, our celebration of the completion of the first half century of its history, that we render tribute to this good man. And he was a good man. And in his modest way he was a great man; his name shall be remembered as long as this Academy lasts; yea, as long as Kansas lasts. It was not until ten years later that I became a member of it, proposed for membership, I am proud to say, by Professor Mudge, and read my first paper before it, almost my first attempt in science authorship. I remember some of its members of those early days, my preceptor in medicine, Dr. J. Robinson, among them. There are others who remember more. Among the founders was another dear friend, my colleague at the University of Kansas for twelve years, Prof. Frank H. Snow. His name, too, like that of Mudge, is engraved in *aes perennis.*

To most of my hearers fifty years is a long time. To me in my memory of those events and of those faces it is as but yesterday. None of its founders now remain and few of its earliest members.

But in science the time has been immeasurably long, long in its accomplishments, longer than all the thousands of years of civilized history prior thereto. I can recall vividly my youthful summary a few years later of the accomplishments of science in the preceding fifty years. They seemed vast to me then in my youthful wonder. The chief things were the electric telegraph, photography, the locomotive, and the conservation and correlation of forces, to which I may now add organic evolution. And great indeed they were, fraught with the germs of our achievements of the past fifty years. One sentence of my college essay lingers in my memory: "Science has made a greater advancement in the past fifty years than in all the preceding centuries!"

He is a learned man to-day who is the master of a very small part of what has been accomplished in these years. Professor Mudge taught me the elements of all the natural and mathematical sciences of those days; at least twenty college teachers of the same to-day would find their subjects wide. There are scores of sciences to-day that have libraries larger than that of all science in those times. There were then perhaps a score of men in the United States who were actively engaged in scientific research, men whose names were known throughout the nation among the scholarly, and perhaps a hundred or two throughout the world; there are thousands to-day, and there will be tens of thousands to-morrow. The profession of science was then precarious, and its emoluments uncertain. The scientific investigator was rarely wanted as a teacher, he was thought to be unpractical and theoretical, for the world at large still looked upon most science as merely bundles of useless theories. College teachers in science as in other branches were usually chosen from among professional teachers or the clerical profession. Medicine was almost the only available avenue to pure science and that was the chief reason why I studied medicine. Perhaps the first chemical laboratory in the state of Kansas was organized at the Kansas Agricultural College in 1873, with Professor Kedzie in charge. The first compound microscope I ever saw was in the same year. The Agricultural College catalogue for 1868 gravely included in its list of its equipment for the teaching of science, a collection of minerals and fossils made by Professor Mudge, an electrical ma-

chine, two Leyden jars, a gas bag and six test tubes. There was but one scientific society then in the United States, and but one or two scientific periodicals; now there are so many that few pretend to know their names even.

Perhaps these few words will convey some conception of the state of science in the United States, and especially in Kansas, when this Academy was born. Do you not then reverence the courage or idealism of those few devoted founders of this Academy which they dedicated to the advancement of science in this, a frontier state?

To recount, even in the most general way, the progress of the sciences in these fifty years is almost beyond the limits of my time and opportunity, to say nothing of my ability. And the subject loomed so large to me that I would have lost courage to undertake it had I not felt conscious of the support my colleagues would give me. They told me, almost all whom I consulted, that the history of each science for the past fifty years comprised its larger part. Told me some of them almost in the words that I had used nearly fifty years before of the progress of science in the preceding fifty years. Will the same be said fifty years hence? I doubt it not.

I may say with assurance that, in nearly every branch of science, progress in these years has been from the descriptive to the analytical, from the search after facts to the search after reasons, for causes; from the *is* to the *why*. Facts are still accumulating, accumulating as never before, but it has been their interpretation and application that has been the basis for the greatly accelerated progress of this last half century. And I think that I can say without fear of contradiction that, underlying all else, were the two great discoveries of the preceding fifty years—conservation of forces and organic evolution. The discovery that heat, light, electricity and force were merely modes of motion was the most fundamental of all, even evolution, for it was in a way but its application to organic life. How like a fairy tale it read to me a few years later.

In biological science the doctrine of evolution has been the foundation of our progress. It was only a few years after the founding of this Academy that Darwin published the last of his famous works on evolution, "The Descent of Man." Previous to 1872 the world at large took only an academic interest in "Darwinism"; with its application to man himself it became of absorbing interest from the cottage to the palace. And as so often when arguments in refutation failed to convince, ridicule and obloquy took their place. It took years to establish the doctrine, but with its general acceptance among scientific men, a new epoch in biological science began, the epoch of analysis and the search for causes. You will pardon the pride I take in saying that the first public lecture in defense of evolution in the state of Kansas, so far as I am aware, was by myself in 1874 at Manhattan. It was a youthful production, with all the assurance of youth, and I suffered for it in the public estimation. Dire things were prophesied for my future. I trust that I have outlived my evil repute of those days.

Even as a boy takes his watch to pieces to see how it is made, we began a half century ago to take things apart, first, like the boy, in the

mere spirit of curiosity to see how they were made, later to find out the laws that govern their construction and to make other things. Analysis must necessarily be the antecedent of synthesis, and synthesis is constructive science. Science for centuries had been more the search for things to prove theories, the handmaid of philosophy. In these years science has been preëminently in the search for theories to explain facts, the mistress of philosophy. It has been in the search for causes and the application of causes in reconstruction. And all this has brought about the correlation of underlying causes, the correlation of the sciences. Then the chief sciences were like islands in a great expanse of water of unknown depths; now they are for the most part united into one land with only valleys at the most between them. Physics and chemistry have been called upon for the explanation of geological and biological phenomena. Physiology and pathology have become merely the physics and chemistry of life; paleontology the history of geology, and so on to the end. And, ever and anon we gaze in amazement at the new fields opening before us in the application of one science to the explanation of another science.

In the science of the universe the application of the spectroscope, discovered only a little earlier, to the determination of the constitution of the sun and stars, has been marvelous in its results; and it has found many new uses. And the application of photography, which antedates our Academy's history not many years, has all been made during these years with equally marvelous results. The larger part of our present knowledge of the sidereal universe has been acquired since 1868. The modern telescope is twenty-five times more powerful than the telescope of the sixties; our vision has been enlarged a million times. The determination of the earth's interior, as rigid and elastic as though composed of steel, has been a discovery of recent years, a discovery which bids fair to revolutionize all our conceptions of the dynamics of the earth.

In geology a better conception of the origin and structure of the earth marks a new epoch in its history. The earth has not been growing colder from a primitive ball of fire; its molten interior no longer exists, and vulcanology has become a new science. An earth of elastic rigidity explains better the base leveling of the continents and the periodic oscillations of the oceans, and indeed all of the great earth movements of the past, and the intimate part they play in its history.

When this Academy was founded I was taught that the boulders scattered over our hills had been dropped there from mighty icebergs in a universal ocean of our continent. But there came a new science of glaciology, and a history of their past in Paleocene, Permian, Cambrian and Proteozoic times. And all these new conceptions of the earth have thrown a flood of light upon the climates and life of the past. And the science of physiography has been born in these years.

When Mudge was the state geologist of Kansas he was thought to be a wizard to unlock all the hidden treasures of the earth. If gold and silver were to be found in Colorado, why not in Kansas? Coal was sought for on the highest bluffs and precious metals and stones in the

limestones, to be found if one dug enough for them. Economic geology has taught us where to look for such things and where the search is vain. A better interpretation of ore deposits, and the relations of ore formation to igneous rocks has enriched the world's resources and saved many, many millions of dollars in wasted efforts. And Kansas certainly knows that the formulation of structural theories of the occurrence of oil and gas reservoirs has added immensely to the wealth of state and nation.

The science of chemistry, too, has been reborn in the years, and its application to man's economic needs is greater perhaps in amount than in any other science. In the days when this Academy was very young was established the law that properties of elements are periodic functions of their atomic weights, as a foundation for the new chemistry. The science of carbon compounds, of organic compounds, has progressed marvelously, and with it the whole science of dye compounds and the synthesis of drugs, based upon the discovery of the space relations of atoms and the reconstruction of our conceptions as to the structure of matter. The theory of ionization and the whole science of physical chemistry are products of these years. Witness, for instance, the successful extrication of nitrogen from the air, and its immense possibilities both in war and in peace. And who knows yet what will result from the discovery of radio-activity in both physics and chemistry? Many new compounds have been discovered in these years.

In none of the sciences does the history of achievement read more like a mythological tale than in the science of physics. Had one, a century ago, predicted them he would straightway have been led to an asylum. In 1869 I well remember that Professor Mudge, in showing his pupils the sparks from a Leyden jar, predicted that before many years electricity would light our streets. And most people thought such a prediction the irresponsible vaporings of a theorist. Let one harken back to the tallow dips of the fifties, the camphene and crude kerosene lamps of the sixties, and compare them with the lights of to-day. How far indeed from the spark of Franklin's kite!

Maxwell, when this Academy was very young, foreshadowed the wireless telegraph in his magnetic theory of light, verified by Herz in the electromagnetic waves, and applied by Marconi to that greatest wonder of all science, the wireless telegraph. Telephony and phonography, discoveries of the early seventies, are now such common and necessary adjuncts of civilization that one wonders how crude things were when they were unknown. And last, but far from least, Darius Green and his flying machine as an established fact may be the final decision in the world's greatest, and we confidently hope victorious war against barbarism. It was a physicist, Langley, who invented it, and physics taught him how. And I have not forgotten the discovery of X-rays and what it means in physics and chemistry.

Stop for a moment and consider what these discoveries and their application in physics mean to us to-day; to converse in living tones through thousands of miles; to imprison our voice to be released at will perhaps a thousand years hence—think what it would mean could the

Sermon on the Mount be heard in the living voice of Christ to-day; to send human messages about the earth through the air with the speed of light; to look through what seemed opaque things; and to fly through the air with the speed and freedom of birds. They almost seem, even yet, to those of us who remember the time when they were not, like the dreams of a disordered mind.

In the biological sciences the records of progress in these years are no less startling. How commonplace have many of these new things become to us in our familiarity with them; how greatly have they modified and are modifying the conditions of human existence.

On the borderland between botany and zoölogy, among those curious organisms that Haeckel once called the Protista, the discoveries of the parts microörganisms play in our happiness and our welfare are most profound. Bacteria, long mere curiosities to the curious, we have recognized as our greatest enemies and our greatest friends among living things, perhaps the greatest of all factors in the development of our race. The germ theory of the early eighties was received, I can well remember, with incredulity; its application to human needs has saved myriads of lives, untold tortures and untold anguish. The mother blesses the day when Pasteur recognized their instrumentality in disease, that saves the babe in her arms. The soldier on the battle field is saved from greater foes than the enemies' guns by that same discovery.

And microzoa, curious creatures they were when this Academy was born; deadly enemies that slay their millions we now know them to be. Mosquitoes, tzetze flies, lice, ticks, rats, then were only annoying vermin; we have recognized them now as hosts of our deadliest enemies. To conquer our enemies we must first know them; we are learning to know them in these years, and whether in the laboratory or on the battle field we shall conquer them. Cholera, typhoid fever, diphtheria, malaria, yellow fever, typhus, sleeping sickness, bubonic plague, have been unmasked. We are driving them from their trenches, and some day we shall conquer the enemy in the great white plague and he shall be no more upon earth. Never again will cholera or black death reap their deadly harvests of the past. Anæsthesia was young when our record begins; it has saved untold suffering in these fifty years. But aseptic and antiseptic surgery was a greater boon, for it has saved untold lives. These discoveries are perhaps not as spectacular as some we have recounted, but who could wish to live in those dark ages of medical science when we knew them not?

Botany is no longer merely the collection and labeling of plants, the science I studied when a boy. It is now a group of sciences, each far greater in extent than the whole subject of those days, aside from bacteriology a science now primarily of plant functions, habits, heredity —physiology, ecology and genetics. To a botanist is due the discovery of the far-reaching law of inheritance, Mendel's law. And De Vries, whatever may be the significance of his discoveries of mutation, placed the whole science on an experimental basis. The study of the vascular anatomy of plants and its service in plant genealogy has transformed

the science; and, like zoölogy, it is no longer the mere tool of geology, but paleobotany, or plant paleontology, has risen to a dignity of its own.

The application of botany to human uses is revolutionizing agriculture, and changing the whole field from an art to a science. Indeed the whole science, to quote Professor Coulter, like so many others, has been made anew in these fifty years.

And what has been said of botany applies with yet greater force to the old science of zoölogy. Then, like botany, it was chiefly a descriptive science, the description and classification of animal life, and as such I studied it fifty years ago. Now it is a large group of sciences dealing with the phenomena of animal life. Its growth even within my own memory has been marvelous. In my youth it was chiefly the study of taxonomy; then the more intimate study of gross structure, comparative anatomy; then of microscopic anatomy, histology; next of the structure and function of the cell, leading naturally into the study of the germ cell, cytology; next the study of habits and environments, ecology; lastly of heredity, or genetics. And each of these was practically a new science, with its own votaries, its own laboratories, its own libraries. More than in any other science evolution was the stimulus of its growth. The search for the factors of evolution led to the theories of Weissman, which, however well they have stood the test of time in their details, served as the inspiring stimulus to experimental zoölogy, which has been the dominant field of advancement in recent years. Mendel's discovery and its rediscovery has been extended from botany to all biological science. And, the more intimate correlation of zoölogy, chemistry and physics has made a new science of physiology.

As in botany, the practical application of the new sciences of animal life to the field of agriculture has given a profound impulse to stock breeding, changing it from an art to a science. And in the fisheries, too, the zoölogical sciences are making great changes.

The science of human anatomy is an old one. As a descriptive science it approached perfection long ago more nearly than any other, because it has to do so immediately with man. As a branch of the great science of animals, zoölogy, it acquired first of all a dignity of its own, and its progress has been along similar lines and in like fields. Advances have been made in the study of the human embryo, of the nerves on the basis of the functional neurone system, in the structure of the cell, and of the protoplasm. Not the least has been the vital culture in vitro of human tissues, with its wide possibilities along new fields of investigations and their immediate application to man's welfare.

The science of paleontology, the history of animal life upon the earth, has ceased to be merely the handmaid of geology. The paleontologist is no longer the mere gatherer of curious petrifactions in the rocks to help the geologist name his rocks. Those lifeless fossils of a half century ago have become alive again, and their teachings have thrown a brilliant illumination upon the origin, relationships, taxonomy and genealogies of organisms. On the border between geology and biology it has united the sciences so that there is no longer even a valley between them. Fossils have explained many things that seemed inexplicable in the structure of

organisms, have solved many geologic problems, and have furnished a rational basis for the science of paleogeography. And above all, it has furnished the best proofs of organic evolution.

It is still largely in the descriptive stage, the morphological stage, because it was the last of the biological sciences to seek for facts. But to the vastly increased accumulation of facts in these years it has applied analysis. Fifty years ago we knew almost nothing of the past vertebrate life of our continent north or south, and comparatively little of other parts of the world. But the rocks have yielded up their secrets to many more searchers in these past fifty years. There can be no classification of animal or plant life without paleontology. There can be no intelligent history of the earth without paleontology. There can be no real knowledge of the structure of organisms without paleontology; no real proofs of evolution without paleontology. And paleontology is doing all these things.

The science of psychology, too, is a product of these fifty years. The little that I learned of it when a youth was embraced in what was called "Mental and Moral Philosophy"; its relation to biology was then very slight, a descriptive science, if science it could be called, like so many others. Its great development in these years has been due chiefly to its intimate correlation with anatomy and physiology and experimental study. There are now hundreds of experimental laboratories where there were none in those days. Mind has been studied as a function of the brain and nervous system in health and disease; the study of abnormal psychology with an immense enlargement of our knowledge of insanity, hynosis, or mesmerism as we called it then, multiple personality and all forms of hysteria. It has taught us vastly about the mysterious thing we used to call instinct in the animals below us, and furnished us an immense increase in our knowledge of their mentality. And finally the application of this knowledge to human needs has been of great aid to medicine, education, business and all industries.

And there are many other sciences which time forbids me even to mention, which have had their birth or been greatly extended in these years. I can say nothing of the mathematical sciences and their applications that have contributed much to advancement in all science. In whichever direction we turn we see the applications of science to man's economies, to his happiness and welfare, yea to his very existence. In the science and art of medicine in particular, we have mentioned some of the contributions of physics, chemistry, botany, zoölogy, anatomy and psychology. In diagnosis, prophylaxis, sanitation, surgery, medicine and therapeutics the doctor of medicine of a half century ago had the feebleness of a child in comparison with his strength to-day. And also in war how terrible have been the contributions of physics and chemistry; how beneficent those of sanitation and the medical sciences. The applications of nearly all branches of science to agriculture have been no less great, no less beneficent. Compare the farmer with his hoe of fifty years ago.

But it is vain to attempt the enumeration of all the gifts science has conferred upon man in these fifty years of the Academy's existence. It is almost another world. The world of fifty years ago considered the

pure scientist as a harmless sort of a lunatic who found pleasure in doing all sorts of silly and foolish things of no or little account to mankind, an impractical theorist at best. And there are still those who ask what is the use? But not many now. Without him there would have been few discoveries, for discoveries and invention are not the results of accident, and man would still be in the infancy of civilization. He is coming to his own, and the harvest is ripe for his sickle.

And our own country has had an honorable part in this advancement of science and its applications. I am not boasting in saying that no other country has done more, that none other will do more in the future. May the Kansas Academy of Science celebrate its centenary as an honorable participant in the coming progress of science.

PART III.

FIFTIETH ANNUAL MEETING.

FIFTIETH ANNUAL MEETING.

GENERAL PROGRAM.

1. Occurrence of Black Flies in Louisiana During Recent Years. E. S. TUCKER.
2. Research Work with Insects Infesting Stored Rice. E. S. TUCKER.
3. Botanical Notes, 1917. FRANK U. G. AGRELIUS.
4. The Common Rocks and Gem-stones of Kansas and How to Recognize Them. M. M. SCHMIDT.
5. Hunting Dinosaurs on the Red Deer River, Alberta. C. H. STERNBERG.
6. The Moraines of Estes Park, Colorado. LYMAN C. WOOSTER.
7. Do Use and Disuse Modify Heredity. LYMAN C. WOOSTER.
8. A Probable Case of Superfetation in the Cow. MARY T. HARMAN.
9. Abnormalities in the Central Nervous System of the Chick. FLORENCE ALSOP.
10. The Origin of Cyclones. A. A. GRAHAM.
11. On the Transmission of the Fowl Cestode, Davinea Cesticillus. JAMES E. ACKERT.
12. War Bread: Corn Starch and High Protein Flour Mixtures for Baking. L. E. SAYRE.
13. Corn Oil. L. E. SAYRE.
14. Aqueous Loess. J. E. TODD.
15. Lacustrine Deposits near Atchison. J. E. TODD.
16. Evaporation in Kansas. CHARLES A. SCHULL.
17. Physoderma zeae, a New Corn Disease in Kansas. L. E. MELCHERS.
18. A Report of the Plant Diseases in Kansas for 1917. L. E. MELCHERS.
19. The Water Relation of Corn and the Sorghums. E. C. MILLER.
20. The Wamego Anticline. J. W. BEEDE.
21. The Algæ of the Water Supplies of Kansas. JAMES B. MCNAUGHT.
22. Correlation of the Formations Described in the Ft. Apache Region in Arizona, with Similar Formations in other Parts of the State. ALBERT B. REAGAN.
23. The Mine Centre District, Ontario. ALBERT T. REAGAN.
24. Contributions of the Drug Laboratory in the University of Kansas in the Enforcement of the Food and Drug Law. G. N. WATSON.

Occurrences of Black Flies in Louisiana During Recent Years.

ELBERT S. TUCKER,
Louisiana Agricultural Experiment Station, Baton Rouge.

Severe outbreaks of black flies in Louisiana seem to be known more as events of the long past than of recent memory. Nevertheless, the insects have doubtlessly occurred every season throughout the later period, either to a negligible extent or occasionally in greater force under especially favorable conditions, as will be noted, in various localities in the northern half of the state. Still no complaint of the pests has been reported directly to the state entomologist for several years back, or at least not since the beginning of 1912. In the files of his office, however, are two reports of investigations made by former agents in regard to local plagues caused by such foes.

Owing to the special interest which was rather recently accorded to the different species of *Simulium* on account of the suspicion that came to be advanced implicating them as conveyors of pellagra, the writer undertook to secure the later facts concerning their existence in Louisiana. As a result, all of the available information which was thus obtained but not heretofore appearing in print is now presented in the following accounts:

Personal encounters with black flies on his home farm at Logansport, De Soto parish, has made Mr. J. B. Garrett well acquainted with the pests. He has stated that in 1897 the flies appeared in such numbers as to harass mules while being used for plowing fields at the time. The insects were then especially troublesome in places along the edges of overflowed land. In order to work the mules in the bordering fields during the height of the prevalence of the flies, the animals were smeared with grease to protect them from bites. While the pests spread into the country a few miles away from their breeding quarters within the flooded areas, they were not known to attack persons. Even though they gathered in such masses on the mules as to mat themselves among the hairs, particularly clinging to the flanks, yet the men working the animals in the fields were only annoyed by the insects flying about the face. On his part, Mr. Garrett has never been bitten by any kind of the flies, notwithstanding the fact that he has been repeatedly exposed to swarms of them. To the best of his recollection, three successive yearly outbreaks occurred, beginning late in February and lasting until about the middle of March. Each time was marked by high water in the Sabine river, which overflowed swamps and lowlands adjacent to its banks. After the water receded, great numbers of pupal cases hung on bushes that had been swept by currents of the flood.

In years when the river did not overflow to much extent or not at all, scarcely any black flies appeared, although larvæ could sometimes be found on bushes, logs and dead branches submerged at the edge of the banks. The conditions for the breeding of the flies in troublesome numbers were always due to extensive spring overflows.

On March 23-24, 1908, after a period of rainy weather, the writer visited Logansport, but found no black flies, since the river had remained at a low stage.

Having been raised on a farm several miles south of Winnfield, in Winn parish, Mr. C. C. Moreland has recollected that about fifteen or possibly twenty years ago the farmers who lived on low flat lands near the creeks in that neighborhood commonly resorted to a method of smudging for protection of horses and mules when being worked in fields. The smoke produced by a smoldering piece of old quilt or some kind of wadding hung from the neck of a draft animal served quite effectively in preventing attacks by the gnats, since the animal in motion generally kept its body enveloped by the smoke. Cattle also obtained relief from the insects by going into the smoke arising from burning logs and brush piles which were set afire for the purpose of creating the smudge. The time of day when the gnats appeared most numerously was towards evening, and they apparently came out of thickets bordering the streams. Occurrences of the gnats always followed high running water in the creeks during early springtime.

While on a trip in Morehouse parish in 1893, Dr. W. H. Dalrymple, the station veterinarian, learned that black flies were afflicting live stock in the country along Bayou Bartholomew. He was afterwards informed by a stockman that the principal trouble caused by the flies resulted from their tendency to enter and clog the nostrils of animals, rendering them scarcely able to breathe, and in fact occasionally suffocating them. Similar accounts concerning appearances of the pest in later years were furnished by the same party. Singularly, the insects caused no serious molestation by biting. Although they flew into the buggy in which Doctor Dalrymple rode, yet he was not bitten, and he has never suffered a bite by a black fly. He suggested that some means of protecting the nose of every exposed animal would be a simple matter in effecting the exclusion of the gnats. For work animals, he proposed the use of screen muzzles, and for grazing animals, the application of repellent substances on the nose.

Owing to his long service in the state, Doctor Dalrymple has had a considerable amount of correspondence in regard to the past. However, he has not kept any records of complaints received and can remember nothing more recent than some reports which came from St. Landry parish, dating back over a number of years.

Many years ago, according to Maj. J. G. Lee, plagues of black flies occurred almost regularly every spring throughout the alluvial lands along the Ouachita river and its tributaries. The infested district mainly included Union, Morehouse, Ouachita, Richland, Caldwell, Franklin and Catahoula parishes. While Major Lee did not live in a place subject to the greatest abundance of the pest, his home at the time being in Farmerville, Union parish, yet he has averred that the insects spread for long distances into hilly country, and, in fact, he has known of their presence in the town of Calhoun. He has suffered from bites inflicted by the gnats at times, but, as a result, he experienced only a sharp stinging effect which soon passed away.

Numerous reports of serious consequences due to the flies attacking persons and live stock are considered by him to have come from very reliable sources. He has heard of cases in which deer sought refuge in

smudges provided for cattle and thus became an easy mark for a shot. These statements, also giving methods of protection and treatment, agree substantially with accounts already mentioned or previously published. However, he has known of no occurrence of the flies, at least in sufficient numbers to have caused any complaint, during the past ten years or more, excepting late in the spring of 1912, when the appearance of a few examples seemed to have attracted just enough attention to furnish evidence that the insect still existed in the region.

In regard to the investigations of agents as first mentioned, both were made on Bayou Pierre, which is considered to be an old channel of the Red river, originating a few miles below Shreveport. South of Wallace lake it forms the boundary line on which the parishes of De Soto on the west side and of Caddo and Red River on the east side adjoin, and it further divides the latter from Natchitoches parish west of the point where the bayou empties into the Red river. The bayou is the outlet of several lakes situated within the eastern border of De Soto parish.

The agent who first visited the stream was Mr. Harper Dean, jr. His notes are dated March 19-21, 1906, and the species of which he found evidence only in the form of pupal cases is believed to have been identical with the one actually collected in the adult stage by Mr. A. H. Rosenfeld on the second investigation in the same vicinity. The determination of this species as *Simulium pecuarum* Riley, which is commonly called the buffalo gnat, has lately been verified through examination of the specimens by Dr. W. D. Hunter, Bureau of Entomology, U. S. Department of Agriculture. This name will likely apply to the flies mentioned by Mr. Garrett as having occurred at Logansport, as well as in the cases reported by Mr. Moreland, Doctor Dalrymple and Major Lee. The results of Mr. Dean's investigation are given as he reported them:

"On Monday, March 19, I secured the services of a guide and proceeded in a boat up the Bayou Pierre for about two miles from the house which I used as headquarters. At this point I visited the 'Government raft' that is thought to be the main breeding place for the gnats that infest the Bayou Pierre section. This raft is about two miles long and about 200 feet wide. It is at present nothing more than a mass of logs jammed into all positions and all in different stages of decay, being overgrown with tangled masses of vegetation. The water under this raft is from 8 to 10 feet deep and during high water the raft is completely submerged. A careful inspection of this raft failed to reveal a single empty pupa case or any indication of the gnats whatever. There were plenty of upright logs in it, yet not a sign of a previous brood of gnats could be found.

"After finishing the inspection of this raft, I proceeded slowly down stream towards the starting point of the morning, and examined carefully every log jam, projecting stump, brush pile, etc., in the stream, as well as the cottonwood, willow and cypress brakes along the banks, all of which are subject to overflow.

"The log jams showed no evidence whatever of a former brood. The brush piles in some instances contained some few empty pupa cases of the last brood, but practically all of the pupa cases were found on projecting stumps in mid stream. All pupa cases found were on the current side of the stream. These were exposed to the full sweep of the current and all were attached to the timber at a height of two feet above the water level at the time, indicating that the last brood, said to have appeared two weeks previous to this date, occurred during a corresponding rise in the stream.

"The insects seemed to have preferred a small stump or projection to one of large size, and also such as was exposed to the full sweep of the current to one protected. Obstructions partly protected from the full force of the current showed but a slight infestation. Again, in the willow brakes, which are also subject to overflow, this same preference was observed, but, on the other hand, few pupa cases were found on the small willows that have smooth bark. A heavy infestation had occurred on the larger willows having rough bark which afforded the best material for inducing oviposition and for the young larvæ to attach their silken threads. A cottonwood brake, therefore, showed a heavier infestation than did a willow brake.

"The bridges spanning the bayou had their pillars covered with the empty pupa cases of the last brood, which also coated the braces of these pillars to a height of two feet above the water level at this time. The current of the stream had produced a strong parallel sweep along the brace boards as well as a strong vertical sweep against the upright pillars.

"On Tuesday, March 20, I went down stream from headquarters for a distance of two miles, engaging in similar inspections as were made on the previous day and obtaining the same results. I observed on this trip that on small sand-bars in mid stream, where they had been left dry by the fall of high water, cottonwoods, etc., showed less numbers of pupa cases than did the stumps and other projections in mid stream.

"A large cypress brake whose trees measured about six feet in circumference showed almost no pupa cases. These brakes were also subject to overflow. From this point down stream, I returned and again visited the 'Government raft,' thinking that the warm midday sun and the cessation of the wind might have brought about some new developments. But there was no sign of the insects whatever about the raft or in the swamps bordering the bayou where they were said to have been most abundant during the outbreaks. In fact, at this time, there were cattle ranging in these swamps unmolested by any insects, and I carefully swept over these swamps in the hope of capturing some adults in the grass where they could find protection from the wind, but this search proved in vain.

"On Wednesday, March 21, I walked to Rambin bayou, a distance of two miles from headquarters. This bayou is thought by some persons to be one of the chief breeding places of the gnats. It never rises so high as does Bayou Pierre, and it is believed that the flat, swampy areas along the bayou, which are protected from winds, furnish ideal breeding places. This bayou afforded just such conditions as these, and I spent a whole day investigating it. The stream was inspected after the manner pursued on Bayou Pierre, as were also the surrounding swamps, but not a single trace of a former brood was obtained in the stream or in the swamps which were swept over and over again.

"All of the deductions in this report are necessarily based upon the traces of the last brood of gnats, as none could be found at the time of my investigation, nor had any been seen for a period of three weeks; therefore, the only thing to do was to study the conditions of the streams and swamps and then use the traces of the last brood as a clue to some of the habits of the insect in question.

"Some reports obtained from the planters of the Bayou Pierre section will be of interest. The planters report that as yet the gnats had not appeared in very great numbers. Only a few specimens had been observed. This brood is said to have occurred about three weeks before my investigation. Last year, about the first of March, during very high water, the gnats were very abundant along the lowlands of Bayou Pierre as well as in the pine woods along its banks.

"Many horses and mules were killed in the outbreak and one man states that he lost three mules from the attacks of the gnats, on March 8, 1905. From all reports, it appears that the gnats made their worst attacks on stock during the hours of early morning and late evening. The outbreaks usually lasted from a week to ten days.

"It has been observed by the planters that, if there were two broods of gnats occurring within a short time of one another, the second outbreak is not nearly so fatal to the stock as the first one. This is no doubt accounted for by the fact that, after the first attack, the stock becomes innoculated with the poison, as it were, following which they are practically immune to the effect of the bites from the gnats.

"Weather notes: March 19 was cloudy and cold; strong N. W. wind all day; mean temperature about 38° F. March 20 and 21, clear and cold; temperature in morning, 28° F."

Mr. Rosenfeld's visit was made in response to a request received March 7, 1908, from Mr. L. S. Frierson, of Frierson, De Soto parish. In his letter, Mr. Frierson reported some personal observations occasioned by a trip which he had taken to the Bayou Pierre on the day before he wrote. Extracts of his remarks are as follows:

"A mile from the river the gnats were quite bad. But near the river none could be seen. On working about a raft of logs I pulled out old pieces of stuff simply swarming with what I conceived to be buffalo gnat larvæ. They would hold onto their homes by attachment at the posterior end of the body and wave about in the water as though they grew out of the stick. But now and then one could be seen to bend over, and, holding on by its mouth, let loose of its tail, which reached around and took a new hold. As soon as it was secure it released the mouth and resumed rythmic motions. The larvæ ranged in size from very young to full grown ones. Many cocoons were already empty. I saw a gnat fly off while I held the stick in my hand. I feel sure that the larvæ represented mixed broods, since I noticed the first brood in January."

The specimens obtained by Mr. Rosenfeld are now preserved in the station collection. His report is quoted from the original records on file:

"Wednesday, March 11, 1908.—Arrived at Frierson, La., yesterday at noon, but rain has so far prevented me from making any field observations on *Simulium*. In the course of a talk with Mr. Frierson to-day, he told me a very interesting little story, which may be of a great deal of importance. It appears that once, while preparing to treat a mule very much swollen and apparently dying from the attacks of buffalo gnats, Mr. Frierson was compelled to leave the mule on account of a severe thunder storm coming on. After the storm, on going out to haul away what he expected to be a dead mule, much to his surprise he found the animal up again on its feet, and the swelling had diminished by fifty per cent. He decided that the cold water must have saved the mule's life, and began treating all following cases of gnat attack by simply almost drowning the animal in very abundant bucketfuls of water. If a stream were near at hand, he hauled the animal out into it. Mr. Frierson is considered to be quite a stock doctor in his vicinity, and he has treated a number of similar cases since that time. He told me that he had never lost a case of gnat attack when the animal had been properly covered with water. The water should be applied in an extremely liberal manner, and the man applying it should not allow himself to desist from the work until a great quantity of water has been applied.

"March 12.—In company with Mr. Frierson I rode down to a bridge over Bayou Pierre, about five miles east of Frierson. Against the pillars of this bridge (this having formerly been visited by Mr. Dean) a number of logs and branches of trees had been lodged by recent high water and were held thus in the swiftest part of the current. I found no larvæ or pupæ on any of the very large logs, but several of the smaller branches, which were standing in somewhat perpendicular

positions in the water, when pulled up revealed the presence of thousands of larvæ and quite a number of pupæ, the larvæ being distributed several feet below the surface of the water. The pupæ seemed to be firmly attached to the supports, but the larvæ can move about freely with a gait similar to that of a leech or measuring worm. The larvæ hold onto their supports in three ways, by the filaments at both extremities and by silken threads which they seem able to produce at will. The majority of the larvæ appeared to be almost full grown, though a number of younger examples could be found. In most cases when sticks were found infested with the larvæ, these sticks were grossly infested, the larvæ seeming to mass together in extremely gregarious fashion. Mr. Frierson said that he remembered cutting one stick which I found heavily coated with gnat larvæ and that he was sure it had not come from a portion of the old 'Government raft' above. The question, therefore, naturally arises as to when the eggs were laid on this stick.

"An investigation of a large portion of the old 'Government raft' about one-half mile above the bridge revealed no gnat stages, although it is possible and probable that numbers of them could be found beneath the logs where the water was moving swiftly. From the top of the raft no swiftly moving water could be seen.

"Mr. Frierson and I then rode to several low and swampy places where the adult gnats had been very abundant a few days previously, but I found very few gnats. I captured about two dozen specimens during the entire ride of eleven or twelve miles, all of them being females. Mr. Frierson informed me that the gnats always haunted more or less the same places, and his assertions were borne out later by dozens of people to whom I talked, both white and colored. These places always seem to be dark, moist areas, and for this reason there is a popular opinion that the gnats breed in swamps. Every man with whom I talked voiced this same sentiment.

"A planter living near the bridge, at whose house I stayed during the later investigations, told me that the gnats always appeared in the early spring after high water, and that they never bothered in the least the teams used in plowing right along the bayou in which the young stages were abundant. Back, however, in the old, deserted lake, land or swamp, there were places where it was unsafe to take stock unless the animals had been previously well greased. Another man on the same plantation told me that the gnats were not nearly so numerous now as in past years. This is probably due in some extent to the cleaning up of the bayou and the reduction of ideal breeding places. Also, another resident in the vicinity informed me that the gnat attacks were always spasmodic and seldom lasted for more than two or three weeks. He said that the gnats had been quite numerous in the back land about a week before my visit, but that they almost invariably disappeared with the advent of any continuous warm weather. I also talked to a number of negroes and they practically duplicated all of the above statements many times.

"March 16.—Mr. Frierson to-day sent me out to the home of Mr. Ernest Glover, so that I could be near the breeding places of the gnats. This house, which was about a mile and a half from the bridge over the bayou, I made my headquarters. On going down to the log jam at the bridge and pulling out some branches and logs, I found the gnat stages quite abundant, being mostly full-grown larvæ and pupæ. Contrary to what I had expected, I found them occurring about as abundantly on logs and sticks lying almost horizontally in the water as on those sticking down perpendicularly. I found them, too, on much larger logs than I had previously observed them to infest. A curious protective adaptation was noticed about these creatures. I took several sticks, on which larvæ were attached by thousands, and placed them in ideally swift water in such locations where I could easily find them when I needed the larvæ for experimental purposes.

"Upon picking these sticks out of the water shortly afterwards, I almost invariably found that a large portion of the larvæ had disappeared. On going back to the place on the next day, I found very few larvæ attached, although the pupæ still remained in numbers. The larvæ seem to realize when they are in danger, and as soon as an infested log which has been taken out of the water is restored to its former position, they release themselves from the log and float down stream to other quarters. All of the larvæ do not immediately forsake the logs thus replaced in the water, the process of desertion being gradual, but a great proportion of the larvæ seem to leave their place of attachment. I observed this characteristic frequently after this time.

"Miall, in describing one of the British species which attach to submerged leaves, says that this feature of releasing themselves is a normal habit, but that the larvæ generally remain attached to their supports by the silken threads which they spin, and shortly after being disturbed, draw themselves back to their original locations. I do not think this action is often true of *Simulium pecuarum.* This feature of their behavior made observations much more difficult than I had expected.

"In order to determine whether the insects bred in still water, I examined numerous twigs and branches in the backwater of the bayou and in several standing water holes and other places between the bayou and the back land, and also many apparent ideal places of attachment in the stagnant water of the back land, but never found the slightest indication of a gnat stage. In all, I examined several hundred possible places of attachment.

"To further test this point, I collected numbers of larvæ from the bayou, leaving them attached to their original supports. and placed them in fresh bayou water held in quart and half-gallon jars with the top left uncovered. Many hundreds of larvæ were given an opportunity to live in this way, but I never succeeded in keeping any alive for more than twenty hours, the length of life when thus confined varying from six or eight on to nineteen and twenty hours, though few larvæ lived the latter time. I also tried confining larvæ singly in small phials with bayou water, unattached to anything, and found that they lived in this way about as well as in the jars. They at first attached to the sides of the phials, and generally climbed up later to the top of the water, where by means of the posterior sucking apparatus they hung head downward, being suspended from the surface film of the water. Upon dying, being heavier than water, all *Simulium* larvæ generally sink to the bottom of the vessel. In the jar experiments, the greater number of the dead larvæ were always found upon the bottom of the vessels. Larvæ hanging to the surface film of water will, when dead, remain floating there until the film is broken.

"March 17.—Secured a boat and paddled up and down Bayou Pierre, trying to determine just where *Simulium pecuarum* would or would not breed. After examining a great number of submerged and floating twigs in the swift current, and partly out of it, and also those plants growing near the banks, I came to the following conclusions: The gnats are seldom found on plants fringing the shore or out of the reach of the swift current. I never found a larva on any plants in such situations. However, in nearly every case where a twig in the full current was pulled up, numerous larvæ were found attached. The number of larvæ seemed to decrease in direct proportion to the strength of the current. Wherever a stick was jammed in between 2 logs through which the water was compelled to flow with a great deal more than ordinary swiftness, the larvæ were found most abundant, generally holding on by the posterior cup and swaying in the water, and creating small currents towards their mouths by rapid swishes of the peculiar many branched filaments of the head. They often, when shifting, secure themselves with a tiny silken thread.

"Miall describes two English species which make a network of these threads in advance of danger, and crawl along them when disturbed. I do not think that *Simulium pecuarum* does this, but that it spins the threads as they become necessary, as a canker-worm would do. Larvæ are beginning to get very scarce now, and I was unable to make very definite observations on this point.

"March 18.—Placed a cage, which I made yesterday, in the water between two logs where the current was running very swiftly. The cage was about 20 x 20 inches, the frame being of wood and having cheesecloth stretched tightly over it. On account of the physical action of the surfact film, however, it is almost impossible to get water to go through any fine mesh, and the cheesecloth is no exception. Even in this extremely swift current, the water inside the box did not seem to move. Larvæ were then very scarce, but I managed to find a few slightly infested twigs and placed them in the cage, although I was compelled to go down the bayou for a distance after them, and had to keep the larvæ in standing water for about five or ten minutes before placing them in the cage. On the next morning, all of the larvæ were dead, and as I could find no more specimens, I had to discontinue the experiment. I do not consider this small experiment as positive proof that the insects cannot be bred in cages, although it looks very much that way, for the specimens were necessarily few in number and had to be kept in jars for a few minutes before being placed in the cage.

"In the afternoon, I went down to a raft about three-quarters of a mile below the bridge and looked carefully for stages of the gnats. All of this raft is out of the main course of the bayou, resting in still water, and I never found a single gnat stage.

"March 19.—Paddled down stream about two miles to another bridge (near which Mr. Harper Dean, jr., had his headquarters two years ago) and examined material in and out of the current all the way down and back. I could find no larvæ anywhere. They seemed to have entirely disappeared. A few pupæ were found on sticks in the swiftest current. The same conditions were found on the raft at the lower bridge. Even in the swiftest current, I could find no gnat stage in any number. The water in the bayou had fallen several feet, and there should have been numerous places on the upper raft, where I had worked, to which the larvæ could have attached in numbers.

"March 20.—After a thorough search in all parts of the bayou for gnat stages, and finding none, I decided to abandon the investigation for the time. It is to be regretted that the work could last so short a season, and if I could have gotten to Bayou Pierre about two weeks earlier, it is probable that more definite conclusions could have been reached. The main issuance of the swarm seemed to have been over when I arrived, and it is significant that during the week I was on the bayou I never saw a single adult gnat, although I looked at the stock in the vicinity quite often.

"March 21.—In riding back to Frierson, my driver took me to several places where the gnats had been unusually abundant, but our horses were never bothered in the least, and the gnats seemed to have disappeared entirely. These places agreed exactly with similar ones that had been shown me by other planters, being swampy and dark."

Further records pertain to two incidental captures made during the year 1912. Determinations of the species are given on the authority of Dr. W. D. Hunter. A few specimens of *Simulium pecuarum* Riley were collected in the window of a car on train at Winnfield, Winn parish, on April 8, by Mr. J. B. Garrett. In the window of the entomological laboratory in the experiment station building at Baton Rouge, May 17, the writer took a single specimen of *Simulium meridionale* Riley, which

species has been given the common name of the turkey gnat. This appeared during the time of high water and overflows of the Mississippi river, although no break occurred near the city, and the only freshly inundated land in the vicinity, except in case of the customarily flooded rice fields, merely lay within reach of backwater on the lake. Evidently no other places than the submerged shrubby banks of the river had been subjected to a flow of water suitable for the breeding of this fly or any related species, and the single capture attested to an extreme scarcity of the insect.

SUPPLEMENTARY NOTES.

Advantage has been taken of the opportunity to append some supplementary notes to the preceding discourse while the manuscript of it was being held for publication. The existence of the first series of these records in the entomologist's office at Baton Rouge did not come to the attention of the writer until after the delivery of the former part had been promised, and finally the later accounts were secured. Their addition here affords further interest, and the initial report gives the exact time of the outbreak of black flies to which previous mention has been made on the authority of Dr. W. H. Dalrymple, with reference to St. Landry parish.

Under date of March 25, 1905, Mr. I. H. Cain of Opelousas, St. Landry parish, La., sent specimens of *Simulium pecuarum* Riley, through a firm in New Orleans, and wrote that he and his son and tenants had lost twenty-one head of plow stock within two days owing to attacks by the gnats. He reported that the insects did not appear in all parts of the parish, but they were most severe in a radius of about ten miles. In this area, they killed nearly 200 head of stock before the owners knew what had caused the deaths. Judging from this statement, the pests were local in their distribution. Their attacks, though lasting only a few days at the worst, were generally made early in mornings and late in evenings. On the date of writing, however, not enough of the pests remained to do any more harm.

As no person living in the infested districts ever saw the particular kind of gnat prior to this occurrence, the owners of stock first believed that their animals suffered and perished from colic. But on learning that the deaths were due to a poisonous effect of bites inflicted by the insects, a mixture called "gnat oil" was applied to the surviving animals and no more stock died, since the treatment kept the flies from biting. Mr. Cain also ventured to say that neither dogs nor buzzards fed on the carcasses, which fact he considered to be strange because the stench of the dead bodies became very offensive before all of them could be burned and destroyed.

In its issue of March 20, 1905, the New Orleans *Picayune* contained a long article about buffalo gnats occurring at Grand Coteau, in the same parish.

The following items may be properly introduced here on account of the proximity of the localities to the bounds of Louisiana. The New Orleans *Times-Democrat*, bearing the date of March 29, 1905, gave a

report of an abundance of buffalo gnats appearing in and about Vicksburg, Miss. On the same date, a resident of Rolling Fork, Sharkey county, Miss., a town situated forty-three miles north of Vicksburg, reported that buffalo gnats had appeared in large numbers in his vicinity on the 8th or 9th day of the month and lingered for two or three weeks. They killed three head of mules on his plantation and as many as thirty-six head in the neighborhood.

Through personal inquiries, further particulars were learned concerning the appearance of black flies, which followed in the wake of floods due to the late inundations from the Mississippi river and other streams on the low alluvial regions of the northeastern part of Louisiana. The first of these overflows occurred in the spring of 1912, and it covered the country south and west of Lake Providence, East Carroll parish. Just a few miles below this place, the inpour of water originated from a crevasse in the Mississippi levee owing to the high flood stage of the river. This break took place in the middle of April. A resident of Mound, Madison parish, has related that during the period of two months in which the water stood on the land he made several trips in a row boat to Tallulah, the parish seat, situated at a distance of eleven miles by rail from his home. He always started out early in the morning on these trips, but for the first few times after leaving the town and while skirting along close to tracts of timber, he was bothered by numbers of the gnats which bit him viciously and did not desist until the sun had risen high above the horizon. On his return home towards evening, the pests again attacked him in the same manner. He described the insects as being small black flies of a humpbacked shape, which inflicted stinging bites.

In 1915, when the river rose to the highest point on record, the levee gave way near Newellton in Tensas parish. Although no report has come to hand which can be taken for proof that any black flies were connected with the ensuing flood on the Louisiana side, yet along the submerged lowlands on the opposite margin of the river, particularly at a place called Allen, a station located between Vicksburg and Port Gibson, Miss., several head of mules died from attacks by such insects before the owners discovered the cause of the fatalities. In fact, the pests have generally been encountered every year in that section of country extending back from the mouth of the Big Black river.

The authority for the statements in the latter cases has further asserted that he noticed a few of the gnats at Tallulah, La., on occasions while the bayou, which passes through the town, was filled with backwater from a flood in the Tensas river during March, 1916. A depth of twelve feet was then attained by the water in the bayou at Tallulah, but the inflow finally receded about April 1, after a duration of three weeks of standing.

The source of this flood was said to have been in Arkansas, and the flow also overspread Bayou Mason, which defines the western boundary of Madison parish. Specimens of the flies were collected by the party to whom reference has just been made, while he was traveling on a train near Gilbert, Franklin parish, La., at the time of the high water. In this instance, the insects flew inside of the window of the car in which he was seated. Moreover, he has reported that he heard of some loss of stock

having then been caused through violent onsets of the gnats in the country not far south of Rayville, Richland parish. Even the Ouachita river, which courses southward in a line as far west as Monroe, La., was sweeping over its banks at the same time, but nothing could be learned that would implicate any outbreak of the pests in connection with the submergence of the marginal tracts of land. However, as Major Lee has referred to an experience with the foe in 1912, which is recounted in the fore part of this paper, the incident may have been occasioned by an event similar to the latter.

At Baton Rouge on March 13, 1915, Dr. W. H. Dalrymple told of an inquiry that had just come to his hand from a correspondent who gave his address as Lloyd, Rapides parish, La. The inquirer desired to be informed of the best treatments to use for protecting farm stock from onslaughts of black flies. He requested this information in order to take prompt action for saving his animals in case the pests should appear again like swarms of them had done at a corresponding time of the year before. Several head of animals in the parish were said to have succumbed to the fury of that invasion.

Examples that were thought to be the species commonly called turkey gnat incidently became noticeable in the lakeside district of Baton Rouge during the last week of April, 1917. A member of the University faculty on one occasion called attention to the effects of a bite which had been inflicted on the lower edge of his eye. The attack took place while he was walking through the campus. On the same grounds a few days later the writer himself happened to feel the sudden grip of an insect on his neck, but killed it with a quick slap by the hand before it could bite. It answered to the species as already mentioned.

Initial Advances in Research Work with Insects Infesting Stored Rice.

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METHODS OF CONDUCTING BREEDING TESTS.

Research work with insects infesting stored rice and its by-products was undertaken by the writer at the beginning of 1912. The breeding of different species of the pests that were encountered in the course of the investigations was conducted under both collective and isolated methods of handling the specimens and material. In this manner, the stock furnished a reserve supply and afforded a check on the isolations.

MANAGEMENT OF COLLECTIVE BREEDING.

Preparatory arrangements for collective breeding were made by placing each accession of infested stock in a suitable receptacle, such as a jar, crock, or can, which, on having the mouth properly covered, served as a cage. The most satisfactory cover used on the utensil consisted of a piece of muslin cloth cut to the desired size, this being fastened over the orifice with a cord tied around the edge. On containers other than those of clear glass, a hole was cut out in the center

of the cover and a glass tumbler or wide-mouthed bottle was placed in an inverted position over the opening. The latter barrier was provided as a trap for the retention of adult insects when they attempted to leave their quarters. These provisions readily facilitated the carrying on of regular observations upon the behavior of the various pests and their parasites so far as the forms appeared in any product held within the chamber. From time to time, the relative abundance and approximate increase or decrease in numbers of a given species in similar or different sorts of stock could be noted almost at a glance.

BREEDING IN ISOLATION.

After some deliberation regarding the procedure by which the several kinds of insects could be successfully bred in isolation, the following measures were devised and employed as offering the best advantages in harmony with storage conditions. They allowed observations to be taken day by day on the developmental phases of any form, whether kept in dark or exposed to light. The perfect determination of life histories depended on the breeding of each species in all of the diverse classes of stock that happened to be found infested by the particular insect. An equalization of other factors was secured by uniform manipulation so far as it proved to be practical for obtaining adequate results.

In the selection of specimens, the adults were preferred for starting a series comprising a number of individuals in a test. When the sexes could not be readily distinguished a few mature forms of a kind were confined together. Otherwise, when possible, active or mated pairs were chosen for the initiative step.

Small tin boxes were utilized for installing some confinements. In most cases, however, the isolations were made in tubular glass vials measuring not less than four inches in length and three-fourths of an inch in diameter. Each vial was provided with a stopper of special construction, designed with the object of allowing atmospheric changes to take effect within the tube in accord with the weather, and at the same time preventing escape of the inclosed insects. These provisions required only a simple device consisting of a tight-fitting cork, through the middle of which a vent of three-eighths of an inch aperture had been punched, the opening then being covered with a disk of fine brass gauze that was attached securely over the inner face of the stopper by means of small pins. By making the insertions at equal distances apart on the rim, no more than four pins were needed for holding the disk tight to the plug. The gauze when properly affixed and trimmed evenly around the circumference protected the cork from being gnawed or burrowed. Such damage was frequently committed by cadelle beetles whenever any portion of the stopper happened to be exposed within the tube containing these insects.

In order to obtain darkened conditions consistent with the habits of secretive insects, the tubes in most instances were placed under cover in pasteboard boxes and tilted so that the contained material and living forms remained together in the bottom of each inclosed space. For comparative purposes, specimens were occasionally left in full reach of diffused sunlight.

OCCURRENCES OF PESTS.

INFESTATION OF ROUGH RICE.

With the first inspection of stocks kept in storage, a quantity of rough Honduras rice that had been held for about a year in a general warehouse in New Orleans, La., was found to have undergone considerable damage by insects. Owing to the cold weather at the time of this visit, which was made on January 17, 1912, most of the pests were encountered in the form of beetles that existed in a dormant state. They hung in scattered numbers among the loose fibers on the dusty sides of the bags containing the rice. When placed in the hand for a while the specimens soon showed signs of life by crawling slowly, being revived by the warmth. The observations concerning the relative abundance and situations in which each kind presented itself are best mentioned in the following order:

The lesser grain borer, *Rhizopertha dominica* Fab. This insect was the prevailing species, most of the beetles being alive but dormant. It occurred most numerously on the outer sides of the tiers of bagged rice, but was also found among the grains.

The rust-red flour beetle, *Tribolium navale* Fab. The beetles of this species were associated with the former, being in a similar dormant condition, but occurring in much less numbers. They were taken mainly on the outside of bags, only a few having crawled in among the grains.

The cadelle, *Tenebroides mauritanicus* L. All specimens of this species of beetle, including a larva, were collected in accumulations of siftings and dust that had lodged in spaces between and beneath the bags of rice. They appeared to be commonly distributed in such material, most of the examples being alive and quite active. Such retreats seemed to be exclusively chosen by the insect for breeding as well as for concealment, since no stage of it occurred in the bagged grain. Yet, in explanation of the presence of three dead larvæ found later in a sample of the same grain, these individuals were believed to have developed in a mixture of siftings which had finally been resacked and replaced in the stacks.

The Angoumois grain moth, *Sitotroga cerealella* Oliv. Moths of this species frequently fluttered and flew away from bags when they were shifted for inspection. These active adults afforded evidence that cold weather had not entirely prevented the breeding of the pest.

The rice weevil, *Calandra oryza* L. The few mature weevils of this species were nearly all found alive, but rather stupid. Only one example, which was much undersized, could be detected on the outer side of the pile of bagged rice. All others occurred among the grains.

The flat grain beetle, *Læmophlœus minutus* Oliv. Adult beetles of this species were scarce, but most of them proved to be alive and active, being found only among the grains.

The short-horned flour beetle, *Latheticus oryzæ* Waterh. This species was not detected at first, but both adult and larval stages were found later by careful examinations of the collected sample of grains. While it exceeded in number that of every other species excepting *Rhizopertha dominica*, yet not as many live stages were detected as in the case of *Læmophlœus minutus*.

The Siamese grain beetle, *Lophocateres pusillus* Klug. Although

very few beetles of this species could be found by later examinations of the sample of grains, the live ones outnumbered the dead.

The book louse, *Troctes divinatoria* Fab. Active specimens considered to be this species were occasionally seen in the powder and dust among the grains.

Eudiagogus rosenschœldi Fah. One dead weevil representing this native species was collected on a bag of rice, and two additional specimens, also dead, were found among the grains. The insect was thought to have been an adventitious introduction from the field, having probably been carried into the grain through the thresher at harvest time. It is not regarded as a foe of rice in any manner.

These statements give an idea of the conditions in which the pests as mentioned specifically pass the winter in stored rice. Reference will be made to these remarks in treating of hibernation.

STATUS OF INFESTATION.

In an effort to determine the status of infestation by the insects occurring in the collected sample of rough Honduras rice, careful search was made for specimens by sorting over the material and picking out all visible live and dead stages of the pests that could be properly identified. The weight of the sample of rice came to exactly three pounds. The results of the examination together with the outcome of a supplementary one, are given in the following tables, the scores being arranged according to the relative importance of the species as was ascertained by the number of stages representing each kind. While the mortality of the stages ran very high, this phase must be regarded as an accumulative result of infestation extending over a period of several months.

Results of first examination, made on March 15 and 16, 1912:

Name of species.	Stage.	No. alive.	No. dead.	Total No.
Rhizopertha dominica	Adult	90	885	975
Latheticus oryzæ	Adult	5	50	55
Sitotroga cerealella	Adult	8	5	13
	Pupa	0	1	1
Calandra oryza	Adult	0	12	12
Læmophlœus minutus	Adult	4	1	5
Lophocateres pusillus	Adult	1	0	1
Grand totals	.....	108	954	1,062

ADDITIONAL.

Troctes divinatoria. Few specimens were found alive in dust, but a reckoning of these was not deemed worth while.

Tenebroides mauritanicus. Specimens taken at time of collection were not included in the count, since they had been picked from between and beneath the bags of the stock. Yet they constituted a small percentage of the general infestation. Larvæ found in second examination, however, were sufficient for a proportionate calculation.

Result of second examination, made on June 12, 1912:

Name of species.	Stage.	No. alive.	No. dead.	Total No.
Rhizopertha dominica	Adult	17	694	711
Lophocateres pusillus	Adult	20	5	25
Sitotroga cerealella	Adult	0	19	19
	Larva	1	0	1
Tribolium navale	Adult	0	10	10
Latheticus oryzæ	Adult	4	3	7
	Larva	3	0	3
Calandra oryza	Adult	1	6	7
Tenebroides mauritanicus	Larva	0	3	3
Læmophlœus minutus	Adult	1	1	2
Grand totals	.....	47	741	788

Additional: *Troctes divinatoria,* numerous.

A summary of the results of the two examinations, including percentages of the proportionate number of live, dead and total stages found according to species, is presented in the following tabulation:

Name of species.	Stages alive.	Stages dead.	Total.
Rhizopertha dominica	107=5.78+%	1,579=85.35+%	1,686=91.14—%
Latheticus oryzæ	12=0.65—%	53= 2.86+%	65= 3.51+%
Sitotroga cerealella	9=0.48+%	25= 1.35+%	34= 1.83+%
Lophocateres pusillus	21=1.14—%	5= 0.28—%	26= 1.41—%
Calandra oryza	1=0.05+%	18= 0.97+%	19= 1.03—%
Tribolium navale	0=0.00%	10= 0.54+%	10= 0.54+%
Laemophloeus minutus	5=0.28—%	2= 0.11—%	7= 0.38—%
Tenebroides mauritanicus	0=0.00%	3= 0.16+%	3= 0.16+%
Grand totals	155=8.38%	1,695=91.62%	1,850=100.00%

The whole number of 1,850 visible stages of the more important infesting insects actually counted in three pounds of rough rice grains gives a quota of approximately 617 stages of the pests per pound. Applying this computation to the stock in storage, every 100 pounds of the grains at the time of the second examination of the sample would be very apt to contain not less than 61,700 living and dead insects, all likely occurring in the adult stage alone. Consideration of eggs, larvæ and pupæ would consequently be in addition. By calculation, however, only 8.38 per cent of the stages were found alive. The proportion of dead ones therefore came to 91.62 per cent.

While these figures afford a basis for comprehending the degree of infestation, they fall far short of a true estimate because of the impossibility of detecting and accounting stages concealed within the grains. Then the probable escape of many individuals from the stock before the sample was obtained, together with other obliterative effects, leaves the question of what would be the full extent of occurrences of the pests in a given time entirely open to speculation.

Since the stock was said to have been grown during the season of 1910, its age from the time of harvesting to June, 1912, covered at least twenty months. The aggregate of the above counts evidently represents a large rather than a small proportion of the entire number of individual pests that had accumulated from infestation extending over this period. The great quantity of dead insects was doubtless due to the dying off of generations, particularly during and after the last winter. Most of the dead adults found by the second examination may reasonably be regarded as having been over-wintered specimens, and the live examples were judged to be representatives of a new seasonal generation. These deductions, of course, must be supported by definite particulars concerning the term of life and behavior of the different species involved. Such data will be presented in accounts of the life history of each species that was studied.

THE ANGOUMOIS GRAIN MOTH.

(*Sitotroga cerealella* Oliv.)

REMARKS ON OCCURRENCES.

According to the status derived by examinations of rough Honduras rice obtained in a general warehouse at New Orleans, La., January 17, 1912, only thirty-four individuals representing the Angoumois grain moth were found in the sample of grains weighing three pounds. On

this basis, the species ranked third in order of importance among the different pests that infested the stock. Previous remarks concerning conditions with regard to this insect at the time of the collection of the infested material need not be repeated here.

Development of stages in the sample evidently progressed without interruption until June 12, the date of the second examination. This course was indicated by the issuance of moths which came out into the light under the glass tumbler on the cover of the jar containing the grains. Although no specimen appeared later than May 9, further evidence of breeding was afforded by the finding of a nearly grown larva during the examination made on June 12. This larva was found wandering freely among the grains, but on being isolated with similar rice, it died within eight days thereafter.

As one or two moths at a time had emerged in February and March, these circumstances gave indication of a continuous breeding of the species throughout the winter and cold weather of spring. However, since the adults, like most other forms of insects that attack stored products, naturally shun bright light, and consequently are not apt to expose themselves in full number to open view, the observations relative to the issue of the specimens from the sample grains have little value towards denoting how much breeding had been carried on by the pest. Then, judging by the spasmodic appearance of the moths at frequent intervals, an overlapping of broods or generations seemed to have occurred and hopelessly confused these phases of existence. On this account, no determinable record could be made respecting the time required for the completion of a life cycle. All the particulars of the life history necessarily remained to be worked out by isolated breeding tests.

OVIPOSITION.

Attempts to breed the species in isolation were begun on March 16, 1912, when five live moths taken during the examination of the sample of infested stock on this date were confined in a tube with sterilized rough rice grains. Owing to a delay in making observations, however, neither the resulting deposition nor hatching of the eggs was known to be effected until April 6, and then the empty egg-shells furnished the only evidence of an issue of larvæ. These shells presented a flattened oval form and still retained a pinkish tint. They were attached in irregular positions on the broad side of the grains, most of them having been placed singly or apart from one another on the surface of the hull, although some were found arranged in a small bunch or else in a short row, with their edges overlapping slightly. In a few cases, as many as five or six shells appeared on a grain, but generally the number per grain ranged from one to three examples.

DEVELOPMENT AND BEHAVIOR OF THE LARVA.

No visible signs of infesting larvæ, except for the presence of the empty egg-shells, could be detected on any of the grains when they were first inspected. Believing, however, that larvæ had issued from the eggs as was indicated by the shells, and then had penetrated in some manner through the hull of separate grains, thus crawling out of sight

on reaching the kernel, examinations of the rice were frequently made at later intervals in efforts to obtain proof of any development of the larval stage. The emergence of a moth on May 9 afforded the first positive evidence of active infestation. Furthermore, the detection of a pupa in each of three other grains was noted on the 15th, 17th and 21st of the same month.

A disposition on the part of the larvæ to wander away for a short distance from their hatching place seemed to be denoted by the emergence of two moths from rough grains that had been kept in different tubes than the one in which the eggs had been deposited. The origin of these moths could be explained only by the probability that newly-hatched larvæ had escaped through the fine gauze covering the vent in the cork of the tube in which they should have remained, and then they had likely crawled to other tubes within their reach, thereby effecting entrance through the same kind of gauze into the interior of the latter. No other way could be conceived that would account for the unexpected cases of introduction in such surroundings. As an extremely minute size of the young larvæ is implied by the circumstances, the ability of the caterpillars to crawl through meshes of coarse bagging cannot be questioned.

The inference drawn from these particular occurrences adds strength to an assumption previously formed that the larvæ at the time when they issue from eggs are capable of engaging in a dispersive movement before they attack grains. This belief is further supported by a contemplation of the probable procedure of the adults in effecting oviposition only between the meshes of sacks filled with rice or else at no considerable depth within the contents, owing to the evident hindrances against obtaining ingress. The point is urged that the occurrence of infested grains within the interior of bags likely becomes due to a dispersal of larvæ in variable courses of more or less length, extending from a prior deposition of eggs which would naturally be expected to have been attached somewhere on the exterior where places of convenient accessibility are offered to the laying parent. Such premises seem to be more consistent than to suppose that a gravid moth could have oviposited on the particular grains at much of a distance inside.

The sign which drew attention to the pupal stage, as will be mentioned later, appeared as a small blotch on the surface of the infested grain. On inserting the point of a pin into the blotch that was first observed, the surface readily parted, and the breach disclosed a pupa occupying a cavity within the kernel. The blotch in this case had been produced on the broad side of the face midway on the grain, but in the subsequent instances, its position was close to the edge or else near an end. While being moderately perceptible to the naked eye in all cases, the discolored surface was found to be extremely thin and slightly puffed outwards when viewed under a magnifier, but yet it always seemed to be intact at this state of advancement.

These observations led to the conclusion that the larva when full grown and about ready to pupate gnaws a place out from its cavity to

reach the surface of the hull, but still leaves a thin epidermal film uncut on the outer face. This action appears necessary to enable the insect to free itself when it matures as a moth, since the adult, not being provided with mouth-parts for gnawing, so far as known, would otherwise be utterly imprisoned in its birthplace and perish there. It is able, however, to break the film, probably by exerting pressure against it, for effecting emergence. The blotch which consequently marks the position of the hollow on the inner side of the hull is the first clue to any injury having been done to the grain. Up to this juncture, the larva seemed to have fed close to the hull, thus forming a shallow channel instead of a perfect burrow in the kernel. In all of such cases, the larva finally pupated within the cavity that it had eaten out during the time of its occupancy.

The matter of working out the particulars of the development of an insect when much of its life is spent in concealment within a product requires special aptitude and patience. Such attendant conditions have to be met in the study of most grain pests inclusive of the present species. Success in prosecuting the work depends on the availability of an ample supply of infested material that will permit losses of stages occasioned by the frequent removal of specimens for examination and still leave a sufficient number for the perfection of observations on the course of life from start to finish.

Owing to the lack of exact data on the deposition and hatching of eggs, nothing more than tentative calculations could be made on the time required for growth of the larvæ. The intervals from date of confinement of the parents until each of the three pupæ was detected, less ten days allowed for the issue of larvæ to take place at the start, cover respectively fifty, fifty-two and fifty-five days for the growth of the larval stage in each instance. With an average larval term of slightly more than fifty-two days, the medial date of pupation fell on May 17. Since the estimates are fully cited in the remarks and schedule given under the concluding topic entitled, "Attainment of a Generation," reference to them should afford a more comprehensive understanding of the reckonings and save their repetition here.

PUPATION.

In the preceding discourse treating of the larval stage, some of the features of pupation have necessarily been mentioned. Further attention, however, is called to the schedule included in the final part of this paper under the heading of "Attainment of a Generation," in which th pupal periods of three additional examples are reckoned. Although the records are insufficient for making a positive calculation of the time required for the development of each pupa, of which the durations were not exactly determined, yet the data will serve to establish a tentative estimate. As near as could be reasonably computed, the pupal period in no instance was less than nine days nor more than twelve days. According to the deductions so obtained, the average time came to nearly eleven days.

Besides the statements already made concerning the pupal stage, but few remarks remain to be given on the subject. Some interest is af-

forded by the position of the pupa with reference to facility in effecting emergence when the insect matures. The head of the pupa that was viewed in its position within the cavity of the kernel rested directly inside of the space marked by the blotch on the hull. Each pupal case observed after the emergence of the adult occupied an exactly similar position with respect to the aperture at this spot through which egress of the moth had been effected. No webs or cocoon inclosed the pupal case. The live pupa was able to twitch vigorously on being pressed or jarred. But one individual has been known to occupy a single grain.

LIFE OF THE ADULT.

The precautionary measure provided by the larva, that allows the adult to emerge through the hull of a grain in which the insect matures, has already been described. As it produces a blotch on the surface, the place is not difficult to detect. After the inmate has liberated itself, the epidermal film, which at first had been left covering the space that the larva had gnawed out on the inner side of the hull, always appeared to be broken outwards by pressure of the moth in effecting its release. The result of the efforts to gain freedom is a circular opening large enough for the insect to pass through and escape. The cap of the opening may be entirely removed or else left hanging by a portion of its edge. In the latter case, it sometimes springs back into place, following the disengagement of the moth.

Should the film which a moth attempts to break be tightly pressed by the face of another grain in a quantity of stock, the possibility of the insect being prevented from forcing an aperture must be considered. In such an event, the adult would surely perish in its birthplace. Considering this contingency, as well as the probable hindrances in other ways which may restrain a moth in undertaking to extricate itself from a mass of grains, in case emergence has taken place at much depth, presents the prospect of the species being more or less subject to mechanical control due to these conditions.

Mating of the sexes is believed to occur after individuals meet in the open air, and the females probably oviposit in the most accessible places on the surface of bagged stock. While the moths may be able to crawl among rough rice, which does not pack as closely as the milled product, yet owing to the obstructive positions of the grains, laying females are not likely to penetrate far beneath the surface for effecting oviposition, even should they readily gain access into a bag. On account of the bagging, for which, however, a coarse texture is used, many adults may fail to find an opening that will allow them to enter a bag. Whether or not gravid moths will deposit their eggs among the fibers of bags in case the grains cannot be reached through the meshes has not been ascertained. At any rate, the depth at which infested grains have been obtained within bags would apparently exclude a moth from ovipositing that far in the interior. In these respects, an explanation should be made that the kind of bag used for handling rough rice is commercially known as a sack, on account of its coarse texture and large size.

Since the moths are commonly found resting on the bags, they are thought to spend most of their lifetime in this manner, although in very dim light, and at nightfall, they hover about on the wing. Reared adults kept in confinement without being allowed to mate at all lived from five or six days to about ten days. On a basis of five records that were obtained in such respects, the data gave an average of eight days for the term of maturity.

ATTAINMENT OF A GENERATION.

According to a published statement, the eggs of the Angoumois grain moth hatch in from four to ten days after deposition. On considering that ten days would afford a sufficient period during moderate weather in early spring to admit of oviposition and the subsequent hatching of the eggs, dating from the confinement of parental moths, which was done on March 16, the resulting issue of larvæ very likely occurred on or about March 26. By using this calculation to fill the gap caused by the lack of timely records, it and the available data on breeding can best be presented in the following schedule. This tabulation is made with reference to the periods of sequential development of stages as were determined in three bleeding tests comprising part of a series. The respective durations are also averaged, and the table concludes with a computation of the number of days required for the attainment of a generation:

Period for deposition and incubation of eggs.	Larval growth.		Pupal term.		Time to maturity.	
	Began.	Days.	Began.	Days.	Began.	Total days.
Dating from confinement of parents on March 16. Estimated at 10 days.	Mar. 26	50	May 15	12	May 27	72
	Mar. 26	52	May 17	11	May 28	73
	Mar. 26	55	May 20	9	May 29	74
Averages	Mar. 26	52	May 17	11	May 28	73
By adding the records of maturity of the three other adults belonging to the same brood, the final calculations will be reduced as follows:					May 9	54
					May 24	69
					May 24	69
Final average for generation					May 24	69

As is shown by the schedule, the time from confinement of parents to the emergence of adults of a new generation ranged from fifty-four to seventy-four days, giving an average of sixty-nine days. On this estimate, as many as five or possibly six generations at least may be expected to occur in a year. Irregularity of development is evident, and summer temperatures may exert an accelerative sway upon the broods. Owing to the incompleteness of records on the breeding of this species, however, much work needs to be done in order to ascertain the particulars of development and seasonal history with exactness and completeness.

Botanical Notes, 1917-1918.

FRANK U. G. AGRELIUS.

As late as October 22, 1917, we observed the following plants in bloom at what is an unusual date:

Diervilla florida Sieb. & Zucc. (*Weigela rosea* of the garden).

Viola pedata Linn.

Spiræa trilobata Linn. (*Spiræa Van Houttei* of the catalogues).

The ordinary dandelion, *Taraxacum officinale* Weber, did not bloom and produce seed during every winter month this season, as it did the winter of 1916-'17. We observed certain facts in connection with this bothersome pest during the summers of 1916 and 1917, in the Rocky Mountains. Here in Kansas it is more or less vexatious. In Colorado it is a serious mischiefmaker in some places, especially in the higher meadows of the alpine region. Where the farmers have previously been able to secure a considerable amount of hay or pasturage, there is practically nothing but dandelions. It is the "English sparrow" of the plant kingdom. And its end is not yet.

POLYCOTYLEDONY OF ANGIOSPERMS.

For some time we have been interested in noting the presence of three cotyledons in certain young plants or seedlings. We found this to be true occasionally in the tomato, especially in some varieties. We marked these plants, intending to observe them later, and to determine whether this characteristic would show any sign of being hereditary. Through oversight and accident we lost these specimens. We have observed none in some tomato seedlings this spring. A former student last year observed this phenomenon in some bean seedlings. Notwithstanding several untoward events, he succeeded in growing one pod to maturity and has promised me the seeds for testing this year. We hope to have some further data on this later.

Kansas State Normal School, Emporia.

The Common Rocks and Gem Stones of Kansas, and How to Recognize Them.

M. M. SCHMIDT.

This paper is not written for the professional mineralogist, but for the everyday student and layman who has not the time nor the means to delve deep into the technical study of the large variety and classes of rocks and gem stones that come to his sight, and yet would like to have some rule or guide whereby he could name and recognize the abundance God has planted in the earth's crust or exposed to his view. There is no one, however disinterested he may be, who has not at some time wondered what some fine colored specimen was that chanced to come to his sight. Rocks fascinate most of us. I can remember quite distinctly when a small boy, I strolled through our pasture and picked up the many beautiful specimens of colored stones and wondered what their

names were, their composition, their common characteristics and how they were placed there. I made up my mind that if I was ever able to name and distinguish them, I would do my best to make it easier for others who might be troubled like I was. Hence the reason for this paper.

It may sound strange to some of us, but Kansas has nearly all the important rocks in some form or condition. Outside of a very few rare gems or crystals, I have found in Marshall county the major classes of all rocks and also most of their subclasses.

I want to make clear in the beginning the classification of five common kinds of rock. Of course there are many, many more than this, but this will suffice us now for this first lesson. We should learn to distinguish and classify the following: Quartz, calcite, feldspar, mica and hornblende. If we learn these five great classes thoroughly, we will be in a fine way to become competent petrologists and able to identify most of the common rocks found in our state. I will take these up singly and discuss their common characteristics, their composition and their various subclasses.

Quartz is one of the most common and abundant. It is quite easily recognized by its very hard, glassy, lustrous appearance. Pure, clear quartz is easily recognized, but the young petrologist is at times confused by its many subdivisions, with its many colors, variegations and forms in which it is found. Quartz is very hard, will scratch glass and cannot be cut or indented with a knife blade. It has no regular cleavage, always breaking irregularly. It is the essential constituent of many other rocks, as granite, gneiss and the sandstones. It is in many instances the cement which binds together the other elements into one mass or stone. In chemical composition it is a union of oxygen and silicon, nearly the same elements of our Portland cement. We recognize fifteen different varieties or subclasses:

Black Quartz, a smoky or black variety.

Yellow Quartz, a clear variety, but yellow or citron colored.

White Quartz, or Milk Quartz, a white, milky colored variety.

Rhinestone, a clear, brilliant variety, also called *Water* diamond, *Cape May* diamond, or *Lake George* diamond.

Amethyst, a beautiful clear purple variety.

Carnelian, a red, waxy variety.

Opal, a white variety, opalescent, with a beautiful play of colors.

Chalcedony, almost like carnelian, but a duller color, not so clear.

Chrysoparse, a chalcedony, but of apple green color.

Heliotrope, a dark green variety, not transparent, flecked with red spots and commonly called bloodstone.

Jasper, an opaque variety, often banded, and in blue or green colors.

Flint, a dull, impure variety of dark gray or black color.

Chert, also a dull flint or purer variety, but very brittle.

Cat's Eye, the substance of silicified trees, which when highly polished, gives a play of colors like a cat's eye, hence the name.

Agate, we recognize three varieties—Onyx, that variety which is always variegated, that is, having distinct bands or lines. Onyx is always banded with white and either black or brown lines. If it was colored otherwise, it would not be called Onyx. *Sardonyx*, just like onyx, only that the bands are of white and red or white and pink or these three colors together. Do not confuse Jasper with the banded agates, although it is just like the agates in everything except that the Jasper has bands of blue or green and the wise men who have named the gems have not seen fit to call Jasper an agate. Then we have also *Moss Agate*. This is a clear stone; it may be almost either of the above classes, but is flecked with spots of moss or other particles which give it distinct colorings.

These fifteen subclasses then are all quartz, and he who would master a common knowledge of stones should bear in mind that no matter which of them he should have at hand, it is essentially quartz and only quartz. He should bear in mind that these are all of various shapes and forms, colors and variegations, but they have all the common characteristics and composition of the great mother class, Quartz, which is recognized reasonably easy.

Calcite is the second most abundant rock-forming material. It is found all over the world and is one of the most common elements of the rocks of our state. It is the major material of our limestones and chalks, the substance of shells and the marbles. It is a gray or nearly white floury material, which is sometimes very soft and can easily be cut with a knife. It occurs sometimes in crystalline form ranging in various colors through blue, green, black or yellow. Calcite is sometimes incorrectly called spar, but there is quite a difference, as we shall presently see, when we examine that substance. In chemical composition it is a carbonate of lime. Under the action of any acid it has the property of effervescing, liberating carbonic acid gas. Its crystals, while very beautiful, are of no use in the arts, as they are too soft and will not retain a polish.

Feldspar is, perhaps, the third most common and important rock-forming material. It occurs most commonly as a cement in the making of other rocks. It has a pearly luster, not glassy like quartz. It is also less hard, but much harder than calcite. It can be scratched with a sharp knife. It weathers more easily than quartz and in weathering it crumbles in grains, is a granulated substance and not a floury or dusty substance like calcite. It is the pearly substance of the granites and gneisses, and with quartz is the cement that cements the materials of the large red boulders found in the northern counties of Kansas, miscalled "niger heads." It occurs in various colors and gives its color to the rock it constitutes. In chemical composition it is a silicate of alumina. Some of its valuable crystals, though not found in Kansas, are the moonstone, a beautiful opalescent gem when properly polished, and the Amazon stone, a beautiful blue-green crystal found near Pikes Peak, Colorado.

Mica is an important rock-forming material and is probably recognized at sight by most of us on account of its utility in glazing stove doors, automobile curtains, etc. It has a perfect cleavage and will scale

off in thin sheets. It is also associated with other rock-forming materials, and in this way makes schist or a mica pudding stone.

Hornblende, called amphibole by some mineralogists, is not so common in Kansas, and is, as far as I am able to find, found only as an accessory of other rocks. It can be identified by its hardness, its shiny black luster, and its flaky appearance. It has some of the characteristics of mica and is sometimes mistaken for it, but a close examination will show that it is much harder than this substance. Mica can be crumbled with the thumb, but not so with hornblende. In chemical composition it is a silicate of magnesia and is about the same in composition as asbestos, to which it is closely related. Hornblende, like asbestos, is a heat resisting material and fire will have no effect on it.

These, then, quartz, calcite, feldspar, mica, and hornblende, are the great mother classes of rocks most common in our state. There are still others, and some of large importance, found here, but these will suffice for this, our first lesson. If we would give a small amount of time and study to these suggestions and compare specimens of each, it would not be long until we would be able to name and distinguish most of our common rocks. This is a knowledge which any one should be glad and proud to possess. We take great interest in many of the studies of the natural world less interesting than this. And what can be more fascinating than an intimate knowledge of the beauty and utility of those massive structures of rocks hidden deep in the bowels of the earth, or here and there exposed to our view, or now and then crystallized and variegated with a beautiful play of colors, as it were, to make us admire them? This is a science that will give pleasure and profit to its student, will take him to the hills and canyons out in the open world, away from the conventions of man and alone with nature.

Home City, March, 1918.

Sternberg's Expedition to the Red Deer River, Alberta, 1917.

Charles H. Sternberg.

In all my experience as a collector, this has been the most successful expedition of my life in the fossil fields of North America. It has also been one of the most strenuous ones. I received sufficient income the year before from my labors for the British Museum to enable me to employ five men part of the time in the fossil field, and to purchase a team and outfit, so I was independent in regard to transportation. Then the season was ideal for the fossil hunter. We had a severe drouth, little rain falling in the fossil beds. This fact also relieved us from the awful pest of a rainy season, the mosquitoes. I might also say, that another strong incentive to labor was the presence in the Sand creek beds of a competitor, even though he chanced to be my own son, Charles M., who was conducting a party for the Geological Survey of Canada. All these causes, and above all others the energy of my assistants, who gave their unremitted labor from sunrise to sunset, not even taking the time to go fishing during the hours we could work in the field—these causes,

and my perfect health and strength, combined to make up the success of last year, even though we went into a country that Barnum Brown, the greatest living collector in America of reptiles, had spent four years in exploring. We found his tracks everywhere, and the network of roads he had built through the bad-lands was of inestimable value to us. Further, on account of our having two outfits in the same field, we were able to assist each other in hauling our finds out of the canyon of the Red Deer river, about 600 feet deep, to the prairie above. My most remarkable discovery was a very complete articulated skeleton of the carnivore *Gorgosaurus libratus*, of Lambe. A larger specimen of this species was discovered by my son, Charles M., in 1913, in the same general region. This has been used by Mr. Lambe as his basis for a memoir published by the government of Canada. My specimen lay on the surface. The upper left ribs and front limbs were destroyed by erosion. A small portion of the end of the tail also is missing. The head and neck were turned back, so the head lay parallel with the illia. The tail, too, was curved towards the head. The abdominal ribs are present for the first time in the history of Cretaceous carnivors, and in position. There seems to be fourteen sets of four each. The right front limb, present and complete, is less than 20 inches long. The ulna is only 4½ inches long, while the metatarsals are 20 inches long. The hind limbs are complete except a few distal phalanges. The skull is normal, with very narrow muzzle. About twenty-seven caudals are present. The illium is about 25 inches long. This specimen is No. 5 in my collection.

The second specimen, discovered by my son and chief assistant, Levi, is a remarkable example of the plated dinosaur *Palæoscincus costatus* Leidy, known only to me by single teeth. The type was one of the famous teeth Dayden had in his vest pocket, when he was run out of the Judith river beds by Black Feet Indians about 1848—the Belly river series of Sand creek, Red Deer river, Alberta. From this region my material came and is of the same age (Pierre) as the Judith River Bells of Montana. This specimen is one of the largest, if not the largest, of the Pierre plated dinosaurs. The entire skull and mandibles are present. Back of the skull are the two half rings of anchylosed plates, and near them another set. Both heads of the scapulæ, with one front limb, are present in place, and enough plates lie slightly disassociated to restore correctly the dermal armor of this huge reptile for the first time to its shoulder. The third set over the neck consists of a central plate with cone-like projection over the dorsal spine, 9 inches long and 6 inches at the base. Along the median line joining this on either side, are great bony plates 26 inches long, 9 inches wide, and an inch and a half thick where they join the middle plate, increasing in thickness to three inches where the great horn-like projection begins to develop. This projection is cone-shaped and a foot long. The ones that follow are still larger. One of the terminal plates is 16 inches long, a foot wide and 9 inches at the base. It is hard to imagine what those over the body measure. The body of these sluggish creatures is as round as a barrel. Some of the ribs are anchylosed to the center of the vertebræ. Beneath the body the plates are either very small, or made up of many rows of small nodules

of bone, that were arranged like chain armor giving mobility to the skin. In this specimen they may be seen for the first time in place. I have seen a pelvic arch of one of the huge creatures six feet across. Some of the ribs are over five feet long.

We secured three *Ceratops* skulls, one of them new. This last is remarkable for its beautiful crest. It is oblong in form, measuring 2 feet 11 inches from the back margin of the orbital opening to the distal end, and it is 28 inches wide. The armature along and behind on the margins of the crest are remarkable, and must have been covered with horn, and made a very formidable weapon of defense. This is No. 48 of my collection.

No. 17 is a very beautiful section of the body, taken from a mold made soon after burial in the clayey sands that covered it. A cast was taken at burial. As the organic remains shrunk and decayed, sand, taking its place, took a perfect cast of the original body. Even the wrinkles of the skin, the shadowy marks of the ribs below, the form of the muscles, and the fat layers along the back, are as perfectly reproduced as if the dead saurian lay before us. Over six square feet of back and flanks are present in hard iron stone. That will last forever and a day. This is a specimen of the peculiar *Stephanosaurus marginatus* Lambe, of which species I had the honor to discover the type in these beds in 1913.

The specimens enumerated above were sold to the American Museum of Natural History, New York, on the recommendation of Barnum Brown, who came here last Christmas to see them.

Another fine specimen is of the crested duck-bill *Corythosaurus casuarius* B. Brown. The type, now mounted in the American Museum, New York, is the finest specimen of a duck-billed dinosaur known. It was preserved in a swimming posture, and with the "mummy" I sold to the American Museum, prove conclusively what I have always believed, the trachodonts are swamp-swimming and feeding reptiles, instead of land, tree-browsing reptiles, as taught by Cope and Marsh.

I have a fine skull. The predentary and a small part of the back of the high crest are missing. It is 2 feet long and 22 inches high in the center of the crest, which is like a helmet, with narrow ridge in center. Or like the Cassowary, from which resemblance Barnum Brown gave it its name. There are eleven continuous vertebræ back of the head, and four scattered dorsals, and twenty-four caudals. The complete sacrum, from under part of centrum to top of spine, is 16 inches. Both illia, pubic bones and ischia are present, the latter with large footed distal ends, and are 3½ feet long, with both femora, 3½ feet long, tibia and fibula, 3 feet 3 inches long, and two metatarsals and three phalanges. The scapula is 2 feet 7 inches long; its greatest width 8½ inches, humerus 21 inches long. This specimen is No. 6, and was discovered by my son, Levi, a few rods from the carnivore.

We have a skull I discovered of *Stephanosaurus marginatus* (I also discovered the type in 1913 with much of the skin impression). The Maxillæ and dentaries show a beautiful series of teeth, both functional and the successional. There are at least 2,000 teeth in this species. It

has a very narrow elevated crest. This induced Lambe to call it the crowned saurian. The teeth have minute denticles along the margins in the front part of the jaws, which are not so pronounced in the back part. Quite a number of the bones of the skeleton were found with this specimen.

I was so fortunate as to find a fine skull of *Monoclonius nasicornis* Brown. My son Levi has beautifully restored it. It lay on the side of a steep slope, part of one side washed down the hill. However, when they were restored, very little was missing. It is the best specimen my parties found in the four years we collected there. It is 4½ feet long, and as far as I know, equalled only by the type in the American Museum, New York, where they have the entire skeleton. I have described these dinosaurs in my recent book, "Hunting Dinosaurs in the Red Deer River, Alberta, Canada," and need not go into details here.

In addition to the dinosaurs collected, I secured a large collection of scattered bones that will be of value as hand specimens to illustrate the wonderful fauna of the Pierre age.

We secured some fine turtles. Two, in fact, have nearly perfect shells. One, Lambe's *Boremys pluchra*, a new species, Levi found in 1913. The other is evidently new, and is the only one I have found in the Belly River Series, either in Montana or Canada, where the ribs are not coössified to the margin. It resembles somewhat the sea tortoises of the Niobrara chalk of Kansas. Then we have a beautifully sculptured plastron of a new species of *Aspiderites*, a form that was not covered with horny scutes, half the plastron of a large *Adocus* that must have been three feet long in life. This shows the marks of very strong horn plates.

Glacial Moraines in the Vicinity of Estes Park, Colorado.

LYMAN C. WOOSTER, State Normal School, Emporia.

While spending his August vacation near Estes Park village, the writer unexpectedly penetrated a region of enormous glacial activity of prehistoric times. Having given years to the study of the moraines of Kansas, Wisconsin, Michigan, Illinois, Indiana and Ohio, belonging to the great continental glacier that once covered the northern United States from Dakota to Cape Cod, the writer became at once interested in these moraines of the alpine glaciers of the Rocky Mountains that formerly filled the upper valleys of the Thompson river and its tributaries.

The introduction to the moraines came when a party of relatives and friends laid a picnic luncheon in the Thompson river at the gateway to Moraine Park. Giant bowlders filled the river, so we were safe from a wetting. The river here falls in cascades one hundred feet through and over the terminal moraine of a glacier that formerly filled Moraine Park. This glacier undoubtedly received tributary ice rivers down Forest, Spruce and Fern canyons and was in its time a glacier of no mean dimensions. It pushed but two or three miles beyond the mouths of the canyons, for it encountered a great glacier from the southwest

and the two stopped in the narrow gap between Eagle Cliff and Giant-track mountains, and here left their front moraines. Later, when the Moraine Park glacier melted back to and up the canyons, the front and lateral moraines impounded the water from the melting ice and thus produced a lake two or three miles in length and nearly one mile in width.

Gradually this lake became filled with silt from the mountains and the moraines, slowly the outlet of the lake lowered its channel through the front moraine till in the course of time the green of dry land replaced the blue of the water, and Moraine Park was formed.

Students of Rock Mountain history will be interested in a bowlder which lies at the gateway to the park which shows that the present mountains were formed where ancient mountains had yielded to the pounding of the waves of an old-time ocean. This bowlder consists of rounded pebbles of granite, mica schist and beach sand, all fused into a compact rock, when the present mountains were crushed and folded and made into a mighty range during the Tertiary period.

On the north side of Moraine Park lies a moderately developed lateral moraine, but on the south side is the remarkable ridge of bowlders from which the park takes its name. At its middle part this moraine rises five hundred feet above the park floor on the north and four hundred feet above the valley of Mill creek on the south. From this middle point the moraine slopes endwise to the eastward till it dies down a short distance beyond the terminal moraine on the Thompson river. From its remarkable development and its straight course, this moraine must have been formed between two glaciers, and is therefore an interglacial moraine comparable with the interlobate moraines of the continental glacier of Wisconsin and eastward. It would be strange if there were not a ridge of gneiss in the axis of this moraine, but no rock in place was observed.

Still further south, between Mill creek and Glacier creek, is another moraine of similar character, but of more massive proportions. Its crest is a thousand feet higher than the crest of its companion interglacial moraine to the north, and it rises 650 feet above the valley of Glacier creek on the south. This interglacial moraine heads near Flat-top mountain and Hallett's peak, and extends in a northeasterly direction nearly to the Y. M. C. A. conference ground. It must have been formed from glaciers that flowed down Mill creek valley on the north and a powerful group of ice rivers on the south, which flowed out of Glacier gorge, Loch Vale and the Tyndall Glacier valley. The southern slope of the moraine is very abrupt and can be climbed by horses only by following a zigzag trail. The northern slope is more moderate and is heavily forested with pine, especially in the vicinity of Bierstadt lake and Bear lake.

Other moraines undoubtedly border the valleys in this heavily glaciated region north of the Long's peak group of mountains, but more time than the writer had at his disposal would be necessary to enable one to make a detailed description of them.

Four miles up Fall river from Estes Park village, a short distance beyond the fish hatchery, is the best developed terminal moraine seen in

the vicinity of Estes Park. Fall river tumbles in a series of cascades over the successive ridges of this moraine down a total distance of five hundred feet. In general appearance, these morainic ridges greatly resemble similar ridges in the bluffs south of Whitewater, Wis., belonging to the moraine of the Wisconsin glacier.

Beyond the terminal moraine of Fall river valley the melting glacier left a lake four miles long and half a mile wide. This in time became filled with sediment and is now Horseshoe park. On either side of the park are weak lateral moraines.

Perhaps the most unique glacial phenomena are shown in the valley of Roaring river, a small stream which joins Fall river from the north near the head of Horseshoe park. The glacier which plowed its way down Fall river valley carried a heavy body of ice, which cleaned out the valley from mountain to mountain on either side and cut very deep, so deep that Roaring river was left with its mouth two hundred feet above the level of the main stream, and is compelled to reach it down a series of waterfalls. Above these falls the river descends two thousand feet in five miles, so rapids and waterfalls characterize the stream nearly to its source. The glacier that plowed out the valley of this river must have been comparatively weak, for even with its high gradient it did not cut as deeply as the one which filled Fall river valley. The weakness of the glacier is still further shown by the number of recessional moraines between the mouth and the source of the stream. The ice river flowed to its junction with the main glacier for unknown thousands of years, in what the geologist terms a hanging valley; then as warmer years succeeded colder years it repeatedly melted back longer distances and advanced shorter distances, till it retreated to its mountain source in the ridge connecting Mount Fairchild and Hague's peak, and ceased to exist as an ice river. The final retreat of this glacier may be seen to-day in a cirque, at the base of the ridge, scoured smooth by the ice.

Just in front of the last recessional moraine of this glacier, at a level five hundred feet below its summit, is Lawn lake, and back of the moraine in hollows in the rock are two or three small bodies of water termed lakes. Snow drifts lie here and there, but with no indication of flowage except in one drift high up on the sides of Mount Fairchild. This has the ribbed appearance later seen on the surface of Hallett's glacier.

Part of the ice that pushed beyond Lawn lake may have crossed over into Black canyon through a low place in the divide now occupied in part by small lakes. This will account for the weakness of Roaring river glacier in the lower part of its course. At about the place of division of Roaring river glacier the right or western arm of this ice river encountered a low mountain, and divided, passing around the mountain and uniting below it. This mountain was thus a Nunatak in a field of ice. Most of the water flows at present on the eastern side. but a small lake was seen in the western valley.

Hallett's glacier was the last objective in this August vacation. Our party, consisting of a nephew, two daughters, a minister and the writer, climbed the ridge connecting Hague's peak with Mummy mountain, from the cirque of Roaring river glacier up a slope covered so thickly with

disintegration boulders that the solid rock of the ridge was nowhere visible; and thence we descended four or five hundred feet to Hallett's glacier. The ridge has an elevation of 13,400 feet above sea level, and gave a fine view of the glacier lying in its cirque below, with its terminal moraine immediately below it. On descending to the moraine we found that it consisted of great, angular bowlders forming a terminal moraine in front of the ice, rising, like so many others in the Estes Park region, five hundred feet above the creek erosion valley below.

Apparently Hallett's glacier has never left the cirque which it has excavated on the east side of the ridge, extending north from Hague's peak, but has continuously shoved out disintegration bowlders, which it has plucked from the ridge behind it, and has thus backed into the ridge. Sometime it will back through where gaps are already visible, and the glacier will cease to exist.

On crossing the ridge connecting Mummy mountain with Hague's peak, the first view of Hallett's glacier was very fine, almost awe-inspiring. The glacier was glistening white from newly fallen snow, and, seen from a height of five hundred feet in its setting of black rock on all sides, one felt like sitting down and studying it as he would an oil painting.

Hallett's glacier is properly a *névé*, and, while it is still alive and has a crevasse where the *névé* drops from a higher to a lower level, the glacier has done little work beyond excavating its cirque and pushing out its great terminal moraine of blocks of gneiss.

The winter preceding our visit had been very stormy, and the cirque was unusually full of snow at the time of our visit in August, so we had no opportunity to visit the crevasse and get a view of the interior of the *névé*. The concave surface of the *névé* is evenly ribbed from back to front. No attempt was made to find the cause of the ribbing, but no other bodies of snow had the ribbed surface except one high up on Mount Fairchild, and it was therefore surmised that the ridges were produced by the motion of the glacier.

The mountains of the Estes Park region consist chiefly of gneiss and mica schist. Even the so-called Pillars of Hercules in Thompson canyon are but the edges of layers of fine-textured mica schist. The bowlders of all the moraines have not been moved more than fifteen miles, most of them not more than five or six. They are, therefore, still angular, like the disintegration bowlders of Hague's peak, and have not been smoothed by sliding. It may be of interest to the mineralogist to learn that many of the bowlders on the slopes of the ridge connecting Hague's peak and Mummy mountain contain twin crystals of feldspar.

Several vacations would be required for a complete study of all these morainic ridges in the vicinity of Estes Park, but such studies would take one into a region replete with gorges, snow fields and rugged mountain peaks, and would fill the hearts of the fisherman, mountain climber, teacher of physical geography, geologist and artist with the deepest pleasure.

Do Use and Disuse Modify Heredity?

By Lyman C. Wooster, State Normal School, Emporia.

In considering this basic problem of evolution, it is evidently necessary to study the dynamics of heredity. The fact that all forms of life inherit the tendencies and powers of their ancestors is unquestioned. Fish beget fish, birds beget birds, and mammals beget mammals, each after its own kind. But how these tendencies and powers are transmitted through the egg, a one-celled body, is not so easy to comprehend.

The microscope shows that the egg consists of a cell wall, cytoplasm, concerned principally with nutrition, and nucleus, the part controlling cell division and bearing the hereditary qualities of the organism. All the parts named, the wall, the cytoplasm and the nucleus, are composed of protoplasm, the physical basis of life according to Huxley. Associated with the protoplasm of the egg are various hydrocarbons and carbohydrates, which yield energy for the cell activities when oxidized, and certain other food materials not yet assimilated.

Naturally the evolutionist is interested chiefly in protoplasm. The chemist tells him that it consists of an unknown number of kinds of protein, many of which are of unknown chemical composition. The biologist with the microscope can distinguish several varieties of protoplasm, chiefly from the fact that they absorb various aniline dyes in different degrees. One of these, which he has named chromatin, absorbs more of the dye stuff than any other, and is the most active kind of protoplasm in the cell in cell division, and hence is most interesting. The other kinds have special work to do in nutrition and in assisting the chromatin, but are not thought to have much to do in heredity. The centrosomes and linin threads, however, merit watching. The centrosomes initiate cell division in most animal cells and in the cells of the lower plants. The linin threads manage the details of cell division.

All the cells of all the tissues are derived from the fertilized egg cell through the process of cell division and growth of each cell from absorbed nourishment. All the daughter cells become specialized in a remarkable way as soma cells. Every cell of the body can do seven things, but the soma cells become specialized so they can do one of the seven things better than they can do the other six. The cells lining the alimentary canal are adept in the absorption of nourishment. The gland cells are wonderful chemists. Other cells are chiefly interested in the excretion of waste. The egg and sperm cells continue the species. The cells of the special senses receive sensations. The muscle cells can contract so as to bring about movements of the parts of the body. The ganglion cells of the nervous system can do or not do many things for the good of the animal.

When the fertilized egg cell divides, each resulting cell has the contract for forming half of the body of all symmetrical animals, or, should the cells separate, the daughter cells may produce identical twins as in man. As the daughter cells increase in number by cell division, and in size through the absorption of nourishment, they assemble in tissues and organs, change their shape and structure, all as

though they were obeying the word of command of some supervising architect. The inherited blue prints in these cases are followed with few mistakes and no cheating. The egg and sperm cells of adult animals have a specialization no more wonderful than that of the other soma cells. They have their special work to do and accomplish it in accordance with the inherited tendencies of their species.

The one question of absorbing interest to all students of life, whether plant or animal, is, Who is the supervising architect, and how are his plans executed? Materialistic biologists have attempted to answer this question, but their biogens, biofors, determinants and energy reactions lie peacefully sleeping in the scrap heap of mere hypotheses.

It is the purpose of this paper to prove by direct evidence, that changes in the habits of animals (and plants as well) are registered slowly but surely in the body-building and body-using instincts of the succeeding generations.

In the Eocene period of the Tertiary era, as shown by their fossil skeletons, little horses grazed on the tender herbage of the swamps of western Kansas and Nebraska. These horses had four well-developed toes on their fore feet and three toes on their hind feet, all being useful in supporting the animals in the bog-lands. The five-toed ancestors of these Eocene horses have not yet been discovered, but skeletons with the missing first digit will undoubtedly be unearthed in the near future.

As western Kansas and Nebraska became higher and drier with the upheaval of the Rocky Mountains, Eohippus depended more and more on speed to escape the wolves and fierce cats. In running the little horses used the third digit chiefly, the second and fourth digits somewhat, and the fifth digit not at all. Slowly the third digits increased in size, and the fifth digits diminished till they became rudimentary and disappeared. It took one million years, according to Osborn, to lose the fifth digit through disuse. In the Miocene Tertiary all the horse skeletons show but three toes. As the horses became larger and the plains higher and drier, the horses used the third digit more exclusively. The third digits with their nails or hoofs grew in size with use and became the main and finally the only supports of the body. The second and fourth digits diminished in size with disuse and are now rudimentary. These digits are represented in the modern horse by the so-called splint bones, rudiments beneath the skin, of the metacarpal and metatarsal bones of these digits. Two additional million years were required to dispose of these side digits and make the American Quaternary horse an apparently one-toed animal.

The instinct in the horse for developing five digits on each leg is not entirely lost. According to Professor Wentworth of our Agricultural College, himself an authority on animal breeding, Dr. J. Cossar Ewart of Copenhagen says that three toes are found in the embryos of all horses at about the fifth or sixth week. In draft horse embryos vestiges of all five toes, according to Doctor Ewart, persist till the same period. Chestnuts and ergots on the legs of horses are usually regarded as representing the hoofs of the missing digits. The paleontologist can furnish dozens of examples showing the influence of environment in causing

modification of parts through use or disuse. Osborn describes the Zeuglodon, which became dog-like after having been a tree-inhabiting animal; later it took to the water and became a fish-like, and later an eel-like mammal.

Whenever a need continues for many years animals not overspecialized against it will modify their anatomy to meet the need, even if it takes a million years or more to do so. Osborn says that all the radiating descendants of a group of hornless mammals may at different periods of geologic time give rise to similar horny outgrowths upon the forehead. The horny outgrowths were long needed for self-defense, and in time they came. Natural selection helped after the horns appeared, but did not start them or make them grow.

The examples are almost numberless wherein the needs of the working cells of the body are impressed on the cromatin of the egg and sperm cells, and the fertilized egg cell has reacted and made provision to meet the need in the course of milleniums of time, but how was the knowledge of the need transferred to the cromatin of the egg and sperm cells? The fact of the transferal is demonstrated; the method of transfer is not understood with certainty.

Several ductless glands, such as the pituitary body at the base of the brain, the thyroids, parathyroids and thymus glands of the neck, and the suprarenals on the kidneys, all have a marked influence in stimulating or retarding the growth of various parts of the body through matter added to or subtracted from the blood. Various glands with ducts, such as the pancreas, liver and reproductive glands, share with the ductless glands the power to send accelerators or restrainers through the blood to various parts of the body. When the pituitary body is injured in a young mammal, such as a dog or sheep, the animal is dwarfed in size, has an excessive development of adipose tissue, and has a delayed or imperfect sexual development. When the same gland is stimulated by disease, unusual growth of various parts of the body takes place. All have observed the remarkable results which have followed the castration of young males, and similar modifications of the development of various parts of the body follow the extirpation of the other glands mentioned.

It is certain that the blood receives from the cells of these glands certain tiny bodies which produce the effects named. Some of these particles, named antibodies, confer immunity to germ diseases; others, named hormones, stimulate the growth of distant organs; and still others, named chalones, depress, retard or inhibit the activity of distant parts.

Jordan says that the germ causing influenza is $\frac{1}{2500}$ mm. by $\frac{1}{5000}$ mm. in size, and the germ of infantile paralysis, measuring $\frac{1}{5000}$ mm., is on the limit of microscopic vision. Beyond these, according to Jordan, are the ultramicroscopic bacteria, beyond the range of vision, some of which can pass through a porcelain filter.

If one-celled plants can be beyond the range of microscopic vision, is it any wonder that tiny messengers sent out by the chromatin of gland cells, or any other cells of the body, should escape observation? These messengers may be poured into the blood by any overworked cell and

hastened in its swift current to auxiliary parts of the body for help in the shape of nourishment and oxygen. Some of these outshoots of chromatin may find developing germ cells and modify to a slight degree the inheritance of the next and succeeding generations. This would be no more wonderful than the changes produced in distant parts of an organism by antibodies, hormones and chalones.

It is fortunate for each species of plant and animal that the changes in inheritance come slowly, keeping pace with the changes in the average environment, otherwise the plant or animal might not survive in its struggle for existence. In the geologic history of the earth many forms have failed to keep pace with their environment, or have advanced too rapidly, and in consequence have perished. Thousands of plants and animals that varied in the wrong direction, or too rapidly, or too slowly, were destroyed in the different periods of the earth's history, but other thousands of their relatives varied with their environments and therefore survived to continue earth's faunas and floras.

While the hormones (stimulators), chalones (retarders) and antibodies (immunizers) may not be alive, they originate in living cells and act on living cells, and hence owe their efficiency in guiding the development of plants and animals to protoplasm energized through life. It is life that is the variable and produces variations in organisms.

Darwin himself fully understood the limitations of his theory of natural and artificial selection. He knew that selection alone could not originate a part of a plant or animal or even modify it. Selection can merely sit in judgment on the work of conscious use or disuse, and reject the individual when it is harmful to the species, or accept the individual when it is helpful. The effects alone of conscious use and disuse of cells, tissues and organs can be inherited. Each tissue and organ had its beginning so long ago in time, and so far down in the plant or animal kingdom, that the cells were at first but slightly modified by life, and millions of years were required to bring the tissue or organ to perfection. Once completed, other millions of years are needed to lose the part, so slowly are species-instincts changed by life through disuse.

A Probable Case of Superfetation in the Cow.

MARY T. HARMAN.

Contribution from the Zoölogical Laboratory of the Kansas State Agricultural College, No. 21 (abstract).

A cow which was mated on December 22, 1916, gave birth to a calf on September 27, 1917. The calf was a normally developed female slightly above the average in size. On October 1 this cow gave birth to another calf, which, according to the decision of the veterinarian, was a little more than a four months' fetus. This second calf was inclosed in the animon, and the placenta was in good condition. Although the calf was dead when born, the death had evidently occurred only a short time previously, as there was no indication of decay.

Abnormalities Produced in the Nervous System of the Chick Embryo.

FLORENCE ALSOP.

Contribution from the Zoölogical Laboratory, Kansas State Agricultural College (abstract).

Abnormalities were produced in the nervous system of the chick embryo by incubating the eggs under different degrees of heat. Some of the eggs were kept in low temperatures ranging from 94°-101° F. Others were incubated at 104°-108° F. Different periods of time were used with all the temperatures, varying from twenty-two to seventy-two hours

The most noticeable abnormality found in embryos subjected to temperatures below normal for twenty-four hours, was the lack of folding in of the neural plates for some distance above and below the primitive knot region. The neural folds in the anterior end of the embryo were generally formed, and these folds extended posteriorly as far as the first somite. Below this point until the primitive node region was reached the flattened neural plate only was developed. At this place the folds appeared again. Not only was the tube formed here, but also extra thickenings of the walls of the tube, and numerous cells, apparently of ectodermal origin, nearly filled the central canal. In some specimens the tube was closed entirely, and in others the excessive tissue filled the canal in such a way that two or three neural openings were present in it. This condition was found more frequently in the forty-eight and seventy-two hour chicks than in those incubated for a shorter length of time.

Another abnormality produced at low temperatures was the curved primitive streak. This was seen in the early stages of development. In these instances the neural folds turned off to the left side of the embryo and formed a curved tube.

A third condition produced was the formation of one neural plate into a neural fold before the other had begun to develop. This lack of development of the neural fold appeared more often in the younger specimens than in the older, because the other neural plate finally formed after a longer period of incubation.

Embryos produced under excessive heat developed different types of deformities than those formed at low temperatures. A large per cent of the abnormalities appeared in the head region. A constriction of the neural tube below the optic vesicles occurred frequently. The optic vesicles and midbrain developed much more rapidly than that part of the brain between them, until a very small neck connected the two.

The effect of high temperatures upon the somites was the reverse of that caused by low temperatures. Nearly four per cent of the embryos incubated at 104°-108° F. developed extra somites lateral to the ordinary somites, while in those embryos produced below 101° F. the number of somites was diminished, or did not form at all in some of the twenty-four hour chicks.

In those eggs incubated at 94°-101° F., sixty-seven per cent were abnormal. Seventeen per cent of these abnormalities were in the brain region. Eighty-three per cent were in the neural tube.

Temperatures between 104° and 108° F. produced ninety per cent abnormal embryos. Forty-six per cent of these were in the head, and fifty-four per cent were in the neural tube.

I wish to express my gratitude and appreciation to Dr. Mary T. Harman, of the Kansas State Agricultural College, for her aid and criticism of the work done in this paper.

The Origin of Cyclones.

A. A. Graham, Topeka.

I have long been endeavoring to collect facts applicable to a theory I have had about storms, *popularly* called cyclones, but *technically* tornadoes, such as passed northwest of Topeka, Tuesday evening, June 5, 1917; and, I believe what I then observed is in confirmation of this theory.

Take a stream at flood, where the rapidly-moving main current is passing a body of comparatively still water in a pocket in the bank, and where the side of this current is in contact with the pocket, a series of rapidly-moving whirlpools is formed, moving from left to right at the right bank of the stream, and from right to left at the left bank of the stream.

Precisely the same is constantly in progress, but less violently in the normal current of streams, and are there called eddies, and might well be compared with the little harmless whirlwinds most frequently occurring in autumn.

Apply to this known fact the principle that liquids, vapors and gasses are similarly subject to much the same laws of motion, and you see I have a deduction rather than a theory; but, as exact science altogether rejects theories and very cautiously accepts deductions, we must find instances in proof.

Now, take the storm referred to. A heavy local rain passed due north over Topeka, accompanied with a gale at the time this damage was done, the rain ceasing about 5:40 p. m., and the sky clearing quickly showed another rain cloud at close range northwest of Topeka, moving apparently in a northeasterly direction, accompanied with vivid lightning and heavy thunder.

The two storms, or currents, had evidently come in contact, and the pressure thus created constituted sufficient resistance to make "whirlpools" between the surfaces of contact.

The velocity and volume of the air current, and whether passing through comparatively still atmosphere or encountering another current and its direction, volume and velocity will determine whether there will be "eddies" or "whirlpools" or cyclones.

The following facts may be offered in further proof:

1. The progressive direction of a cyclone is comparable with the edge of the storm cloud.

2. The direction of rotation of the "twister" conforms with the direction of the whirlpools at the edges of the current of a stream.

3. The shape of a typical cyclone, when appearing alone, or as a projection downward from a cloud, is exactly that of the cavity of a whirlpool, funnel-shaped, and is formed by the suction downward of the cloud to fill what corresponds to the cavity of a whirlpool in a stream.

4. The damage is done by the twisting rotary motion of the atmosphere, thus accounting for things being thrown in every direction, and not by rapid lateral movement; for, as with the whirlpools in the stream, the forward movement of a cyclone is sometimes quite slow.

5. Cyclones, as here explained, should occur in "twins" sometimes, one on either side of the rain current; and this actually did happen just one week later, June 13, 1917, a few miles farther west, near Wamego.

July 13, 1917.

On the Transmission of the Fowl Cestode, Davainea Cesticillus (Molin).

JAMES E. ACKERT, Kansas State Agricultural College.

In the vicinity of Manhattan, Kan., a large percentage of the fowls are infested with tapeworms. Of 161 chickens examined, 121, or 75.1 percent, had tapeworms in their intestinal tracts. The infestations ranged from one to two or three hundred, and in one instance a young chick harbored 443 of these parasitic worms. Fourteen to twenty-seven cestodes is common, and this number usually makes a visible effect upon the fowl, causing emaciation, loss of feathers, and general debility. The average infestation for the 161 chickens was 26.7 tapeworms per fowl.

Examinations of numerous poultry yards for possible intermediate hosts of chicken tapeworms gave strong circumstantial evidence against house flies. The latter were abundant, while other invertebrates were comparatively rare. It was found that the behavior of the house flies was not unlike that of the chickens. In the early morning they were moving about in the sunshine, but as the heat of the day came on the flies went to the shade, alighting upon the stones and the shady side of buildings. The fowls likewise were actively feeding in the morning, but by ten o'clock were in the shade, the young chicks pursuing flies while the old birds were preening their feathers. In the shade of the poultry house flies were crawling over the floor and feeding upon feces, which contained tapeworm embryos.

From fowls in the United States six different species of cestodes have been collected. Of these, *Davainea proglottina*, (Davaine), rare in this country, may be transmitted by a slug (*Limax cinereus*). Another, *Choanotænia infundibuliformis* (Goeze), may be transmitted by the house fly, *Musca domestica*. The means of transmitting any of the remaining four species was not known until the past summer, when an experiment demonstrated that the housefly may transmit to fowls another of these cestodes, which appears to be *Davainea cesticillus* (Molin, 1858), Blanchard, 1891.

The fowls used in the experiment were hatched in an incubator and placed at once in a fly-proof field cage, where they were given food free from animal tissues, with the exception of an occasional feeding of care-

fully selected beef scraps. Flies taken from nature were placed in small, lantern globe, cages, where they were given living embryos from fowl cestodes and kept alive as long as possible, in order to afford time for the development of larval tapeworms (cysticercoids) in the bodies of the flies.

By giving to the caged flies small amounts of whole sweet milk daily, fairly large numbers of them were kept alive for two or three weeks after they were fed the tapeworm onchospheres. Upon the death of these flies, they were either preserved for sectioning, or given to young chickens reared in the fly-proof field cage. In this way several hundred house flies were fed, a few at a time, to twelve chickens.

In the fowls examined to date, nine cestodes have been found, two from chick No. 165 being sexually mature. Control fowls from the same broods kept with the experimental chickens in no case yielded a single parasitic worm. (Control chicks have been kept constantly in this fly-proof and worm-proof field cage for four years, and in no instance has a control chick been infected with a helminth). That the two mature tapeworms from chick No. 165 are apparently *Davainea cesticillus*, is seen from the following diagnosis: Length, 79 to 90 mm. Maximum width, 1.6 to 2.3 mm. Head cylindrical, 0.5 to 0.6 mm. wide and 0.3 to 0.4 mm. long. Suckers unarmed, about 0.1 mm. in diameter. Rostellum broad and hemispherical, 0.29 mm. wide, armed with approximately 200 very unstable hooks. Hooks 8 to 9 microns long, with long ventral root and short dorsal root. Neck very short, followed by proglottids equal to or greater in width than the head. Anterior proglottids 3 to 6 times as broad as long; the following increase in size until they become equal in length and breadth and finally longer than broad; borders overlapping. Vagina and cirrus pouch pass on the dorsal side of the two excretory canals and nerve.

Male Reproductive Organs: Testes, 20 in number in the posterior portion of the proglottid. Ves deferens coiled before entering the base of the cirrus pouch, also coiled within the latter. Cirrus pouch ellipsoidal, 139 to 164 microns long by 65 to 82 microns wide. Cirrus when protracted, 131 microns long and 13 microns in diameter, armed with minute spines, and with a bulbous enlargement 21 microns in diameter at its base, where it becomes continuous with the cirrus pouch.

Female Reproductive Organs: Vagina enlarged before reaching the median line into a small seminal receptacle. Ovary occupies the middle field in front of the testes. Yolk gland and shell gland posterior to the ovary, ventral and dorsal, respectively, in relative position. Uterus at first in front of the ovary; gradually increasing in size, it finally occupies most of the segment, extending laterally to the excretory canals. In the oldest proglottids it becomes divided into compartments or capsules, each containing a single egg. Embryo, 35 by 31 microns in diameter, with a very thin membrane closely adherent to its surface. Embryo further enveloped by a thicker, smooth membrane, oval in shape, 42 to 36 microns in diameter. Latter surrounded by a thin, wrinkled membrane about 66 to 61 microns in diameter. Egg surrounded by a capsule composed of an outer and inner membrane.

War Bread—Corn Starch and High Protein Flour Mixtures for Baking.

L. E. Sayre.

Under present-day conditions, with large areas unproductive through the ravages of war, and a shortage of cereal crops in other localities, the question of bread production is a most serious one. In America we have depended largely upon wheat to supply this staple food. Corn, rye, and other grains have been used but sparingly, or only locally. In Europe white bread is almost unknown. Potato starch, rice flour, barley flour, corn meal, and other substitutes are being mixed with their bread. In Great Britain, under present laws, this mixture ranges from twenty to fifty per cent. This situation is bringing home to America the necessity for radically changing her diet. If each American will use for food during the year 1918 not less than two bushels of corn, this will release 200 million bushels of wheat, which, with the surplus already available, will allow us to export to Europe over 300 million bushels. This will win the war.

Corn has always been the staple article for bread making in certain sections of our country. Of late it is finding more and more favor as a food stuff. It is replacing wheat as the source of other commercial products, as well as adding other food stuffs to our dietary. Formerly starch was made entirely from wheat and potatoes. In every pharmacopœia in the world, except that of the United States, wheat starch is official. So it was here in the United States until 1890, when corn starch was made to take the place of wheat starch, and the former became recognized for the first time as official. Other corn products which may be mentioned in this connection are corn syrup and corn oil. The former is well established in our dietary, while the latter is destined to form a most important addition thereto.

Investigators have recently attacked the question of our bread supply in the light of these conditions, and have turned their attention to various substitutes for wheat flour and to mixtures of wheat and other flours. The question as stated in an article by Prof. E. H. S. Bailey is, "Do these substitutes fully take the place of wheat, and would it be wise for us to adopt their use in the interest of economy?" He then refers to the use of potatoes in food flour. He says: "If we compare dried wheat and dried potatoes, *i. e.*, the products when all the water is eliminated, we find the wheat is three times as rich in proteins as potatoes. On this account, when we diminish the wheat content in bread, we lower the protein content. In other words, we lower the content of the food which furnishes energy." Doctor Bailey also refers to the suggestion of others that corn flour might well be substituted for wheat when the latter is scarce. He remarks that "to a certain extent this is true, but here again is a product not so well adapted for bread making unless used with other cereals when bread is raised by means of yeast. Corn is not lacking in proteins and contains in addition a relatively large percentage of fat. The attitude of the government has thus far been against the use of mixed flours, or those which contain rye or corn

mixed with wheat flour. This has largely been because there was a chance for adulteration of wheat flour if the practice were allowed. Many flours are, of course, used as ready-to-cook pancake flours, etc., but the small tax and the regulations imposed have prevented any adulteration of wheat flour."

It is important to make clear in this paper that "corn flour" is a different article from that which is frequently used in the baking of biscuits and other articles of that kind, known as a cornstarch flour. Corn flour, we learn, is a product of the hominy industry and is the corn kernel ground with only a part of the hulls and the germ removed in a dry process. Therefore, corn flour contains about seven per cent of protein and a considerable amount of cellulose, while the cornstarch flour contains no protein, practically, and no cellulose. Cornstarch flour now on the market is claimed to be superior in food value to corn flour, as the former contains none of the indigestible fiber.

The gluten of corn has none of the rising qualities so characteristic of wheat gluten, hence it is of no particular value in bread baking, and for that purpose may be rejected. Starch flour is rendered more digestible by heat. This is especially valuable when bread is toasted. It is to be noted that we eat bread for its energy-giving qualities, its starch content contributes to this end. We turn to milk, eggs, meat, beans, etc., for proteins. Among the experienced bakers corn starch has become popular and its popularity is increasing. Its cost is from two to three dollars per barrel less than wheat flour; reduces shortening and sugar bills, increases the yield of bread, and our experiments have shown that from 10 to 40 per cent can be added to wheat flour in the making of bread, crackers and sweet goods. It becomes a matter of practical interest, therefore, to study its merits. Our own experiments in laboratory and kitchen have been confined to bread mainly in the utilization of the mixtures above noted. We have found that a high protein flour of 14 per cent and the corn starch mixed in the proportion of 33⅓ of the latter and 66⅔ of the former gives a loaf which is larger and, in every respect, an improved bread loaf—superior to that of bread from pure flour alone.

A tabulated statement of the results of the four varieties of loaves is appended. The process of manipulation as performed in the food laboratory by Mr. Lantz, under our direction, is also given.

RESULTS.

Loaf.	Weight of dough.	Weight of loaf.	Loss in weight.	Volume of loaf.
1	389.0 gms.	373.2 gms.	15.8 gms.	1,090 cc.
2	384.0 gms.	364.8 gms.	19.2 gms.	895 cc.
3	396.5 gms.	372.5 gms.	24.0 gms.	1,130 cc.
4	390.9 gms.	376.7 gms.	20.0 gms.	960 cc.

METHOD USED.

Warm the flour to 33° C. Dissolve the sugar, yeast, and salt in water (about 90 cc.) at 32° C. Pour this solution over about half of the flour and mix thoroughly into a sponge. Put sponge into an oven at 32° C. and let rise for 45 minutes. Mix in the remainder of the flour, knead for about five minutes, put into the 35° oven, and let rise for 15 minutes. Again remove from oven, knead for about five minutes, put back into

35° C. oven and let rise for 15 minutes. Again remove from oven, knead for about five minutes, but back into 35° C. oven and let rise for 65 minutes till the dough is at least twice as high as it was when put into oven. When put into the oven this last time the dough is placed into the greased pan and the top of the dough is greased. Bake for 35 minutes at an average temperature of 195° C. Average time total for this method, 3 hours and 30 minutes.

RECIPE USED.

14 per cent protein flour (pure or mixed with corn starch)	240 gms.
Sugar	11 gms.
Fleischmann's Compressed Yeast	7 gms.
Salt	3 gms.
Water (68 per cent)	164 cc.

Second series of tests, comparing mixtures of corn starch flour with 14 per cent protein flour and 11 per cent protein flour.

Loaf number, and composition.	Weight of dough.	Weight of loaf.	Loss in weight.	Volume of loaf
1. 25% corn starch and 75% of 14% protein flour	463.2 gms.	441.0 gms.	22.2 gms.	1,140 cc.
2. 33⅓% corn starch and 66⅔% of 14% protein flour	421.3 gms.	397.8 gms.	23.6 gms.	1,045 cc.
3. 25% corn starch and 75% of 11% protein flour	414.0 gms.	395.5 gms.	18.5 gms.	1,095 cc.
4. 33⅓% corn starch and 66⅔% of 11% protein flour	427.2 gms.	408.7 gms.	18.5 gms.	1,110 cc.

The recipe was the same as the above with the exception that the water used was regulated to suit each loaf. The following is the respective amounts of water used:

Loaf No. 1, 180 cc.; loaf No. 2, 168 cc.; loaf No. 3, 163 cc.; loaf No. 4, 163 cc.

The method was the same as the one previously employed with the following exceptions:

(1) 100 cc. of water, was added to make the sponge instead of 90 cc.
(2) The oven for the sponge was kept at 40°–42° C. instead of 35° C.
(3) The sponge was let rise 30-35 minutes instead of 45 minutes.
(4) The temperature at which the bread was baked was 180°-210° C. or an average of 195° C.
(5) Each loaf was baked for 30 minutes instead of 35 minutes.
(6) The time required for each loaf to rise to proper height in the pan the last time before putting into the oven to bake was as follows: Loaf No. 1, 1 hr. 40 min.; loaf No. 2, 1 hr. 42 min.; loaf No. 3, 1 hr. 53 min.; loaf No. 4, 1 hr. 46 min.
(7) Total time required in this process, less than 4 hours.
(8) By mistake an excess of water (above the 180 cc. required) was added to loaf No. 1 and this accounts for its larger volume and greater weight.

I have been permitted to use in this article a formula for bread which has been used in large batches for bakers' bread, and which contains about 10 per cent of corn starch. The following is the formula:

3 gallons water.
¾ lbs. C sugar.
½ lbs. corn oil.
33 lbs. flour.
3 lbs. corn starch.
6–8 oz. yeast.
3–5 hour dough; 27–35 minutes in proof box.

This dough should go to the oven when it is one-half inch from the top of the pan, so it will give a nice bloom in oven and will stand 5–6 degrees more heat.

By using corn starch and carrying out the above directions, this bread will be sealed from the outside and will retain the moisture longer than H. O. S. or corn flour and will not shrink.

I have had submitted to me various formulæ for the use of flour in making various kinds of crackers, vanilla wafers, graham crackers and other cakes. In these formulæ corn oil is used in place of other shortening material. This accounts for my interest in baking flour mixtures. Reports on these mixtures cannot be given at this time, but I am inclined to the opinion that the use of corn starch flour and a high protein flour in connection with corn oil for shortening and the other usual constituents, has a merit worthy of study. Attention should be called to the above table where it will be noted that No. 2 and No. 4 loaves fell when put into the oven. This undoubtedly was due to the fact that there was some fault in the application of heat or in the regulation of the same. In my experiments with these mixtures I have had, to say the least, splendid results.

During the past year mixtures of various percentages of corn starch and high protein (14 per cent) wheat flour have been sent to a number of housekeepers asking for their opinion of the bread which would result from the baking by the ordinary kitchen methods. In every case very favorable reports have been received, some of these stating that the bread was more palatable and nutritious than the ordinary bread made from patent wheat flour.

In connection with the interesting subject of the baking qualities of different flours, it may not be out of place to refer to what others, high in authority, have to say, gleaned from published articles and through personal correspondence.

The statement is made by I. S. Chamberlain (U. S. Department of Agriculture, Bureau of Chemistry, Bull. 81, 1904) that bread made with a flour whose gluten contains as little as 20 per cent glutenin rises well during fermentation, but flattens in baking. If it contains as much as 34 per cent glutenin the dough neither rises during fermentation nor in the oven. Variation of 2 per cent in glutenin gives rise to differences in bread which are quite recognizable to the expert baker. J. T. Willard and C. O. Swanson (Kansas Agricultural Experiment Station Bull. 177, 1911) state that in comparing flours of the same class there is no correspondence in the relation of the percentage of gliadin in the protein to the baking qualities of flour, but there is a comparing of flours of different class. Baking qualities depend as much on physical properties of flour as upon the percentage of protein or gliadin.

In correspondence with Professor Swanson, I learn from him that he does not think that the percentage of protein or gliadin by themselves are determining factors. The percentage of protein is an indication of the amount of gluten in the flour, but tells nothing about the quality of this gluten, and quality is more important than quantity. Neither does he think that the relative percentage of gliadin and glutenin is a determining

factor. Two flours may have the same percentage of alcohol-soluble protein, but differ very greatly in baking qualities. In a series of mill stream flours, all made from the same wheat, the percentage of gliadin will be higher in the better grades, but this is as far as the comparison goes, so far as he knew.

Professor Swanson thinks we shall have to work out the baking factors separately. For instance, a certain set of factors controls the absorptive capacity. Another set of factors controls loaf volume, another what we may call adaptability for a variety of purposes. Then the problem is complicated by the fact that the same factor may enter into several of the characteristics. He thinks that no progress will be made upon these lines until we take up some of the fundamental problems. The development of collodial chemistry ought to be a great help. The electrolytes are possibly of more fundamental importance than we have thought.

However well a flour may be adapted for bread baking, so far as physical qualities are concerned, its value in our dietary will depend entirely upon the digestibility of the finished product. Accordingly experiments have been made as to the comparative digestibility of breads, using artificial digestion. The results show that one bread is as digestible as the other—that of wheat flour alone, and that of the corn starch mixture. It may be in place to state that any experiments, however modest they may be, which contribute to the subject of wheat conservation at this time, are of interest, and if these point only to a line of work which others more competent and better equipped may follow up to some definite and practical conclusion, it would help to further the solution of the problem of food conservation.

Recent experiments on nutrition have more clearly than ever emphasized the importance of mixed diet, and because of the bearing these have it may be well to give a brief review of some of them in so far as they may touch upon the subject in hand. In the first place, it may be stated that dieticians are now making some fine distinctions as to what is efficient and what is comparatively inert as food material, and we are more than interested in watching how these fine distinctions are employed. Furthermore, recent scientific investigations have shown that the proteins of different foods are not alike, nor have they the same degree of efficiency. Each food substance has what may be termed efficient and deficient proteins. The gelatine of meat may be regarded as a deficient protein, since it does not contain the full quota of amino-acids. Another example of deficient protein is gliadin of wheat; still another is zein of corn. All of these protein substances, however, yield nitrogen, and by computation may show protein values, which may be misleading. The fact seems to be that laboratory analysis is no indication of the real merit of proteins. An examination of foods in the chemical laboratory does not tell anything at all about their actual nutritive values. The same ambiguity arises in feeding; if, for example, corn is fed with oats, the results are better than if each were fed alone.

We occasionally find a rather misleading comparison made between the value of the protein of wheat and that of corn, by comparing inefficient zein with the glutelin of wheat. Although maize protein contains zein in a large amount, the next most abundant protein, glutelin, of

corn, has been shown to yield all the amino-acids which zein lacks, and as it is probable that the remaining proteins likewise yield them, the amino-acid efficiency of zein is thus more or less supplemented when the entire feed is fed. (Osborn and Mendel, Journal of Biological Chemistry, Vol. 18, No. 1.)

Doctor Osborn (American Journal of Physiology, Vol. 20, p. 447) states: "It is interesting, however, to note that these amino-acids, which are lacking in zein, are all present in notable proportions in this (alkali-soluble) protein, so that the mixture of the proteins as they occur in this seed (maize) yields all the amino-acids usually obtained from protein substances." Of late, corn proteins have been criticised for the lack of lysine, which wheat gluten contains. However, Dr. E. V. McCollum (Journal of Biological Chemistry, Vol. 18, No. 2, 1917) found conclusively through feeding experiments that lysine is not the limiting factor which determines the biological value of the corn proteins. In fact, he found that in certain instances the protein which does not yield lysine serves to enhance the value of certain proteins. As stated before, a mere chemical examination of foods does not throw much light upon their actual nutritive values; and when mixtures are fed, the nutrition problem is, in proportion, difficult of solution.

If the whole wheat plant alone forms the sole ration for animals, disastrous results occur. The same is true to a less extent if the corn plant forms the sole ration. This is true also with other grains. In the all-wheat ration malnutrition sets in, caused not only by deficient protein, but also through poisonous substances found in the germ. (Hart, Miller and McCollum, Journal of Biological Chemistry, Vol. 25, June, 1916.)

We find the proteins of corn are 40 per cent efficient, for milk production, while wheat proteins are only 35 per cent. Considering the efficiency of proteins for growth, McCollum found that corn alone was nearly 30 per cent, while wheat alone was only 15 per cent. He also found that young rats cannot grow more than about half as fast as they should on good diet, if their ration contains a low wheat protein content of poor quality. All this shows that it is unwise to have one grain predominate in a ration for man or animals, but each grain supplements the other to more or less extent, and each is benefited by the other. In other words, a combination of two grains is always better than each by itself. It is foolish to condemn one grain, and prefer another. Each has its place in our diet, and there is room for all.

In the series of experiments which I have conducted to determine the digestibility of bread made from mixtures of wheat flour and corn starch, the following procedure was employed: Three samples of bread were selected. No. 1 represented a bread made from a mixture of 66⅔ per cent high protein, 14 per cent flour and 33⅓ per cent corn starch. No. 2 represented a bread made from Bowersock's "Zephyr" flour, which is a high patent flour made from Kansas hard wheat. This bread was made in one of the homes and is that which is commonly called "home-made" bread. No. 3 was a sample of "baker's" bread, such as is served in hotels and restaurants.

The three bread samples were simultaneously heated in an oven at 110° C. for a period of thirty minutes. This treatment rendered the bread dry and friable and easily pulverized. One-gram samples (in duplicate of each bread) were taken for the digestion experiments and treated as follows:

In the salivary digestion each sample of the dried and pulverized material was treated with 10 cc. saliva (1-10 aqueous solution) and digestion was carried on for one hour at 37° C. At the end of this period the digestion mixtures were filtered through tared filter papers and the residues, after being allowed to dry spontaneously and later at 110° C. for one hour in a hot-air oven, were weighed. The weights of the residues were as tabulated below:

I	0.456 gms.
I* (duplicate)	0.495 gms.
II	0.465 gms.
II*	0.484 gms.
III	0.365 gms.
III*	0.394 gms.

These residues were then treated with 100 cc. of a pepsin solution (1 gm. scale pepsin dissolved in 100 cc. N/10 HCl). This digestion was carried on for six hours in a 37.5° C. incubator. At the end of this period the digestion mixtures were filtered through tared hard filters as in the previous experiment with salivary digestion. The residues were dried and heated at 110° C. for one hour in a hot-air oven and then weighed. The weights of the respective residues were as tabulated below:

I	0.150 gms.
I*	0.119 gms.
II	0.205 gms.
II*	0.334 gms.
III	0.180 gms.
III*	0.155 gms.

These second residues were then subjected to pancreatic digestion for six hours at 37.5° C. The pancreatic fluid was made by dissolving 1 gm. of Merck's pancreatin in 100 cc. of 1 per cent $NaHCO_3$ solution. Each residue was treated with 50 cc. of the pancreatic fluid. At the end of the digestion period the mixtures were filtered through tared filters, allowed to dry and later heated at 110° C. for one hour in the hot-air oven. The residues were then weighed and compared as per tabulation below:

I	0.075 gms.
I*	0.068 gms.
II	0.143 gms.
II*	0.125 gms.
III	0.095 gms.
III*	0.079 gms.

Summary and Interpretation of Results.

It will be seen from the above that in the first amylotic digestion that the following percentages of digested material were produced:

I	1 gm. — 0.456 = 0.544 gm., or 54.4%
I*	1 gm. — 0.495 = 0.505 gm., or 50.5%
II	1 gm. — 0.465 = 0.535 gm., or 53.5%
II*	1 gm. — 0.484 = 0.516 gm., or 51.6%
III	1 gm. — 0.365 = 0.635 gm., or 63.5%
III*	1 gm. — 0.394 = 0.606 gm., or 60.6%

In the second experiment, or gastric digestion, the following percentages of proteolytic digestion products were produced:

I	0.465 gm. — 0.150 = 0.306 gm., or 30.6%
I*	0.495 gm. — 0.119 = 0.376 gm., or 37.6%
II	0.465 gm. — 0.205 = 0.260 gm., or 26.0%
II*	0.484 gm. — 0.334 = 0.150 gm., or 15.0%
III	0.365 gm. — 0.180 = 0.185 gm., or 18.5%
III*	0.394 gm. — 0.155 = 0.239 gm., or 29.3%

In the third experiment, pancreatic digestion, the following percentages of pancreatic peptones and soluble products of digestion were produced:

I	0.150 gm. — 0.075 = 0.075 gm., or 7.5%
I*	0.119 gm. — 0.068 = 0.051 gm., or 5.1%
II	0.205 gm. — 0.205 = 0.143 gm., or 6.2%
II*	0.334 gm. — 0.125 = 0.109 gm., or 10.9%
III	0.180 gm. — 0.095 = 0.085 gm., or 8.5%
III*	0.155 gm. — 0.079 = 0.076 gm., or 7.6%

From the data obtained above the total soluble digested products were calculated and found to be as follows:

I	92.85%
II	81.15%
III	91.30%

It would therefore be inferred from this data that the order of digestibility of the various breads would be as follows:

1. Bread made from a mixed flour composed of 66⅔ per cent high protein flour and 33⅓ per cent corn starch.
2. Baker's bread (the exact composition of this bread was not learned).
3. "Home-made" bread, made from a high patent Kansas hard wheat flour.

The manufacturers are constantly striving to improve their products and adapt them more thoroughly to the conditions which confront us to-day. Since these studies were begun a product has been announced which is claimed to be superior to the corn flour already used. This new product is called "corn gluten flour." The manufacturers say that it "contains about 7 per cent of protein, 1 per cent of oil, the balance starch. It does not contain any fiber. We consider this latter fact a decided advantage, since it makes this product a truer substitute for patent wheat flour, which is practically fiberless. Other wheat substitutes contain from 1 per cent to 13 per cent fiber, which of course makes them less digestible."

Corn starch, when mixed with ordinary patent flours, furnishes as acceptable a loaf and in every way as satisfactory in lightness, porosity, calorific value as that of patent flour. The breads of the latter variety have been made in our Home Economics department.

The one property which the addition of corn starch seems to contribute is that of porosity. The patent flour seems to make a very fine and comparatively compact loaf, spongy and light. The greater addition of starch seems to contribute porosity. The crust of the bread of the corn starch mixtures does not brown as nicely as the patent flour, but gives a very light yellowish brown crust, which is very satisfactory. We have tried combinations of the high protein flour 50 per cent, corn starch 25 per cent, and corn meal 25 per cent, which makes a very nutritious loaf, and from many standpoints a more nutritious bread.

Price of Douglas Baker's Pure Food Corn Starch, $5.15 per hundredweight in bags, $5.20 in barrels, f. o. b. Kansas City.

Another phase of the investigations which have been instituted in the search for wheat substitutes has been the testing of various materials which have had a very limited use heretofore in bread making, as well as to inspire investigations of materials formerly considered waste products. In line with the former is an article in the American Food Journal for December, 1917, by Elizabeth C. Sprague and Ethel Loflin, of the home economics department of the University of Kansas. In this article the use of flour from rye, oats, barley, rice, and kafir corn are discussed. They conclude that "even with a considerable shortage of wheat there need be no shortage of bread, as long as we have a good supply of other cereals. It is evident that we must depend upon wheat in a large measure for the texture, lightness and flavor of our bread, but that wheat has no unique nutritive value. 'The demand for wheat bread represents a habit of mind and palata rather than any nonreplacable need.' The real and great need is the production of these flours on a commercial scale, their sale at a reasonable price, and their use not only in the homes but in bakeries. With the more refined methods of milling applied to these grains and the production of finer flours, larger proportions of each might be used. In the light of our present experience, we feel justified in advising the use of 25 per cent of any of these flours."

As an example of the search for wheat flour substitutes among what were formerly considered waste products, may be cited the article in the *Cracker Baker* for January, 1918, by H. Steinson, on "Coffee and Charcoal Biscuits and Coffee, Something New for the Progressive Biscuit Manufacturer." He says in part: "Just how much of the coffee flour should be used in a barrel of wheat flour would have to be determined by experimenting. The following recipe is suggestive, and may form the basis for some biscuit maker to take up the making of such biscuits. I see no reason why they should not become a staple article. The recipe or something similar will certainly make a palatable biscuit. I am told a coffee flour of good quality could be made and sold for fifteen to eighteen cents a pound. The biscuit maker will note that coffee flour costs less than the shortening, at present, and he knows he gets pound for pound of the coffee back, but not of the shortening used in a barrel of flour.

COFFEE BISCUITS.

Flour	198 lbs.
Coffee flour	30 lbs.
Yellow sugar	20 lbs.
Shortening	20 lbs.
Soda	1 lb.
Ammonia	1 lb.
Salt	2 lbs.
Honey	6 lbs.
Water (about)	40 lbs.

"The above made into a dough, is handled much the same as any other hard, sweet biscuit, such as arrowroot. The mixer should run well for an hour, and the baking of the dough should be proportionately well done. When so handled, the biscuits take on a fine, smooth finish, which receives and retains clear-cut impression and lettering."

An analysis of coffee grounds by us shows that they may be expected to be highly nutritious, as they contain crude fat 13.17 per cent, protein (N x 6.25) 11.84 per cent, fiber 28.22 per cent, and practically no sac-

charine material. Coffee grounds, if made into a powder as fine as flour, is worth experimenting with, since they contain as unexpectedly large percentage of fat and a like proportion of protein, and during the process of baking no caffein could remain should there be any unextracted alkaloids in them. Some crackers made by us and flavored with cinnamon or ginger have proven quite palatable. As to their value as a dietary, it will take some time to determine and give any satisfactory report.

Prices of corn starch flour January 10, 1917: 100 pounds (Chicago), $3.05; 100 pounds (Lawrence), $3.29.

From *Bakers Weekly*, December 2, 1916. File. Addenda to article for Kansas Academy of Science, January 12, 1917.

Determining the Strength of Flour.

Prof. T. B. Wood, Cambridge University.

After seven years of investigation the author has worked out the following theory on the strength of wheat flours, which has finally enabled him to devise a method which promises to be both accurate and rigid, and to require a very small amount of flour. The strength of a wheat may be defined as the power of making a large loaf of good shape and texture. Evidently strength is a complex of at least two factors, size and shape, which are likely to be quite independent of each other. Not infrequently, for instance, wheats are met with which make large loaves of bad shape or small loaves of good shape.

A FEASIBLE IDEA.

It seemed a feasible idea that the size of the loaf might depend on the volume of gas formed when the yeast was mixed with different flours. On mixing different flours with water and yeast it was found that for the first two or three hours they all gave off gas at about the same rate. The reason of this is that all flours contain about the same amount of sugar, approximately 1 per cent, so that at the beginning of the bread fermentation all flours provide the yeast with about the same amount of sugar for food. But this small amount of sugar is soon exhausted, and for its subsequent growth the yeast is dependent on the transformation of some of the starch of the flour into sugar. Wheat, like many other seeds, contains a ferment or enzyme called diatase, which has the power of changing starch into sugar, and the activity of this ferment varies greatly in different wheats. The more active the ferment in a flour, the more rapid the formation of sugar. Consequently the more rapid the yeast will grow, and the greater will be the volume of gas produced in the later stages of fermentation in the dough.

ESTIMATING THE SIZE.

From these facts it is quite easy to devise a method of estimating how large a loaf any given flour will produce. Twenty grams of flour are weighed out and put into a wide-mouthed bottle. A flask of water is warmed at 40° C. Of this, 100 cc. is measured out and into 2½ grams of compressed yeast is intimately mixed, 20 cc. of the mixture being added to the 20 grams of flour in the bottle. The flour and yeast water are then mixed into a cream by stirring with a glass rod. The

bottle is then placed in a water bath, which is kept at 35° C. The bottle is connected to an apparatus for measuring gas, and the volume of gas given off every hour is recorded. As already mentioned, all flours give off about the same volume of gas during the first three hours. After this length of time the volume of gas given off per hour varies greatly with different flours. Thus a flour which will bake a large loaf gives off under the conditions above described about 20 cc. of gas during the sixth hour of fermentation, whilst a flour which bakes a small, light loaf, gives off during the sixth hour of fermentation only about 5 cc. gas. Having devised a feasible method of estimating how large a loaf of any given flour will make, the problem of the shape and texture still remains. Previous investigators had exhausted almost every chemical property of gluten in their search for a method of estimating strength. The author therefore determined to study its physical properties. Now gluten is what is known as a colloid substance. Such substances can scarcely be said to possess definite physical properties of their own, for their properties vary so largely with their surroundings. Their properties are profoundly modified by the presence of chemical substances. Wheat, like most all plant substances, is slightly acid, and the degree of acidity varies in different samples. Accordingly the effect of acids on the physical properties of gluten was investigated and it was found that by placing bits of gluten in pure water and in acid of varying concentration it could be made to assume any consistency from a state of division so fine that the separate particles could not be seen except by noticing their presence made the water milky, to a tough coherent mass almost like India rubber. It was found, however, that the concentration of acid in the wheat grain was never great enough to make the gluten really coherent.

CHEMICAL ANALYSES.

But wheat contains also varying proportions of such salts as chlorides, sulphates and phosphates, which are soluble in water, and the action of such salts on gluten was next tried. It was at once found that these salts, in the same concentration as they exist in the wheat grain, were capable of making gluten coherent, but that the kind of coherence produced was peculiar to each salt. Phosphates produce a tough and elastic gluten such as is found in the strongest wheats. Chlorides and sulphates, on the other hand, make gluten hard and brittle, like the gluten of very weak wheat.

The next step was to make chemical analyses to find out the amount of soluble salts in different wheats. Strong wheats of the Fife class were found to contain not less than one part of soluble phosphate in 1,000 parts of wheat, while Rivet wheat, the weakest wheat that comes on the market, contained only half that amount. Rivet, however, was found to be comparatively rich in soluble chlorides, and in very small amounts in strong wheats of the Fife class. After making a great many analyses it was found that the amount of soluble phosphate in wheat was a very good index of the shape and texture of the loaf which it would make. The toughness and elasticity of the gluten no doubt depend on the concentration of the soluble phosphate in the wheat grain, the

more soluble the phosphate the tougher and more elastic the gluten, and a tough, elastic gluten holds the loaf in shape as it expands in the oven and prevents the small bubbles of gas running together into large holes and spoiling the texture.

MEASURING TURBIDITY.

These facts suggest at once a method for estimating the shape and texture of a loaf which can be made from any given sample of wheat. An analysis showing the amount of soluble phosphate in the sample should give the desired information. But unfortunately such analysis is not an easy one to make and requires a considerable quantity of flour. In making these analyses it was noticed that when the flours were shaken with water to dissolve the phosphate, and the insoluble substances removed by filtering, the solutions obtained were always more or less turbid, and the degree of turbidity was found to be related to the amount of phosphate present and to the shape of loaf produced. On further investigation it was found that the turbidity was due to the fact that the concentration of acid and salts which make gluten coherent also dissolve some of it, and gluten, like other colloids, gives a turbid solution. It was also found that the amount of gluten dissolved, and consequently the degree of turbidity, is related to the shape of the loaf. Now it is quite easy to measure the degree of turbidity by pouring the solution into a glass vessel below which a small electric lamp is placed and noting the depth of the liquid through which the filament of the lamp can just be seen. The turbidities, however, were so slight that it was found necessary to increase them by adding a little iodine solution, which gives a brown milkiness with solution of gluten, the degree of milkiness depending on the amount of gluten in the solution.

THE METHOD.

The method is as follows: One gram of flour is weighed out and put into a small bottle. To it is added 20 cc. of water. The bottle is then shaken for one hour. At the end of this time the contents are poured into a filter. To 15 cc. of the solution 1½ cc. of a weak solution of iodine is added, and after standing an hour the turbidity test is applied. Working in this way, it is possible to see through only 10 cc. of the solution thus obtained from such wheat as Red Fife, as compared with 25 cc. in the case of Rivet. Other wheats yield solutions of intermediate capacity.

Corn Oil.

L. E. Sayre.

Corn oil is defined by the United States Government as "the edible oil obtained from the germ of corn, maize (Zea Mays L.) (Food Inspection Decisions 169). Of this oil there was manufactured in the United States in the year 1916 (later figures are for the moment not available) approximately eighty-two million pounds. As this oil is a by-product from the corn starch and similar industries, it can be manufactured and sold more cheaply than can those vegetable oils which are primary products of manufacture.

Certain physical and chemical properties of this oil have commended it to us as a substance which might well find a place in our dietary. In appearance it is pleasing. It contains little or none of the products which cause oils to become rancid quickly, so that its keeping qualities are excellent. It has a very low melting point, while at the same time it has a high smoking point, as compared with some other materials in common use. For example, lard smokes at 350° F., refined cottonseed oil at 500° F. and corn oil at 600° F., while corn oil has the lowest melting point of the three. Refined corn oil has been used both as a food and in hospitals as a substitute for olive oil, and has been pronounced superior to the latter. As a food this oil is used as a salad dressing, as shortening in bread and cracker baking, and as an ingredient of oleomargarine and lard substitutes.

The writer has devoted considerable study to this oil in its various food relations, and in a paper presented before this Academy last year pointed out some of its qualities which would indicate that it would prove a valuable addition to our dietary. Since that time further experiments have been made by the writer, and additional reports have been obtained from housekeepers who have tested it.

The data obtained during the past year bear out the earlier conclusions concerning this oil. As a salad oil the refined corn oil is superior both to olive oil and to refined cotton seed oil, many persons finding it the more palatable of the three. When used in a salad dressing, such as mayonaise, it emulsifies with the egg more easily than do these oils, and so is better adapted to this use. It has also been found to be superior to these oils in its digestibility. Other investigators have pronounced it high in nutritive value, declaring that it contains a very high amount of those necessary bodies known as vitimines. The writer, then, feels that his former conclusions are fully substantiated and that this oil is now proven to be worthy of a permanent place in our dietary. One difficulty in its earlier introduction into general use has been the fact that the manufacturers have sold it only in barrel lots. Now two firms are placing on the market under their trade names refined corn oil suitable for domestic use.

Current price to retailers, 2 dozen pints, $7.50; 1 dozen quarts, $7.

Aqueous Loess.

(Abstract.)

J. E. Todd.

If one includes in the definition of loess that it is of eolian origin, our subject expresses an absurdity, but if the term is still to be employed in its original sense, it should imply certain physical characters without regard to the way in which they have been produced. Typical loess is generally recognized as being a light, yellowish gray or buff silt of impalpable fineness, having, when dry, the rigidity of rock without its hardness, and when thoroughly wet a plasticity which causes it to creep and fault and to show prevalent columnar jointing. Some would confine the term to Quaternary deposits, and that is usually the usage.

Elsewhere the writer has indicated some cases of eolian loess (Kan. Acad. Sci. Proc. 1916.), also similar deposits of aqueous origin. (Iowa Acad. Sci. Proc., Vol. XXVI, p. 356.) A few years ago he called attention to the probable different age and origin of the lower part of the loess at Kansas City, Mo. (Mo. Geol. Survey, Vol. X.) This paper is to emphasize its later date and aqueous origin. It is sixty to eighty feet in depth at many localities and is probably of early Wisconsin origin.

The reasons for believing in its aqueous origin are the following:

1. The terrace-like form of the deposit. At Kansas City, Mo., it forms a distinct bench along the north side of the city, with its top 125 to 150 feet above the river. Most of Kansas City, Kan., agrees in height. Also at Leavenworth and at other localities, given in a later section.

2. The occurrence of distinctly water-laid strata in the lower part of the terrace, and a gradual and indistinct passage upward into typical loess. This has been observed at the Kansas Cities, St. Joseph and Sioux City.

3. The low level of the base of the formation. This is usually very little above the level of the flood plain of the present stream, or 25 or 30 feet above the stream itself. This is in marked contrast with the usual bank of the stream, which is 150 to 200 feet of Carboniferous strata capped with till and loess. Moreover, this deposit occurs in bends or coves of the highland bluffs, as though it were in remnants of an old channel once deeply filled with it, and from which the present deeper channel has since been excavated.

Besides the localities already indicated, it has been noticed along the Missouri below Forest City, Mo., near Iowa Point, Kan., and along Wolf creek, a little above its junction with the Missouri. It appears along the Kansas near Armstrong, Muncie, Edwardsville, Holliday, Bonner Springs and northeast and northwest of Lawrence. The typical loess along the Missouri has the lighter buff color prevalent in the later sediments of that stream, while along the Kansas it is darker reddish, as if derived more from carboniferous shales.

This deposit has been so connected with the higher loess, which is probably of eolian origin, by wind action, hillside wash and creeping, that all have been considered one formation.

March 23, 1918.

Lacustrine Beds Near Atchison.

(Abstract.)

J. E. Todd.

It has been known for several years that there is thick deposit of sand exposed at Spaulding's quarry, a little northeast of Atchison, Kan.

The quarry is in the upper Oread limestone, its top being over fifty feet above the level of the flood plain of the Missouri. Upon the limestone lies a stratum of chert gravel, 8-10 feet in thickness, and upon that 50-60 feet of rather fine sand. Over all is 10-15 feet of Kansan till capped with 25-30 feet of loess. Northern erretics occur occasionally in the upper part of the sand, but not below. The sand corresponds in age to the

Aftonian beds of western Iowa, and were thought at first to be a river deposit like them, but further study has shown them to be uniformly fine and evenly stratified.

Similar beds have been found south of the creek which enters the Missouri south of the union depot, in the river bluffs and at frequent intervals for three or four miles southwest. A fine exposure occurs half a mile southwest of Forest park, on the north of the creek, where a cliff of slightly consolidated sand stands fifty feet high, which is capped with ten feet of till, the lower part of which is banded as though laid in water.

It appears, therefore, that the deposit was not the direct work of the Missouri, for it lies in the valley of a tributary rather than of that stream itself.

The most rational interpretation yet suggested is the following:

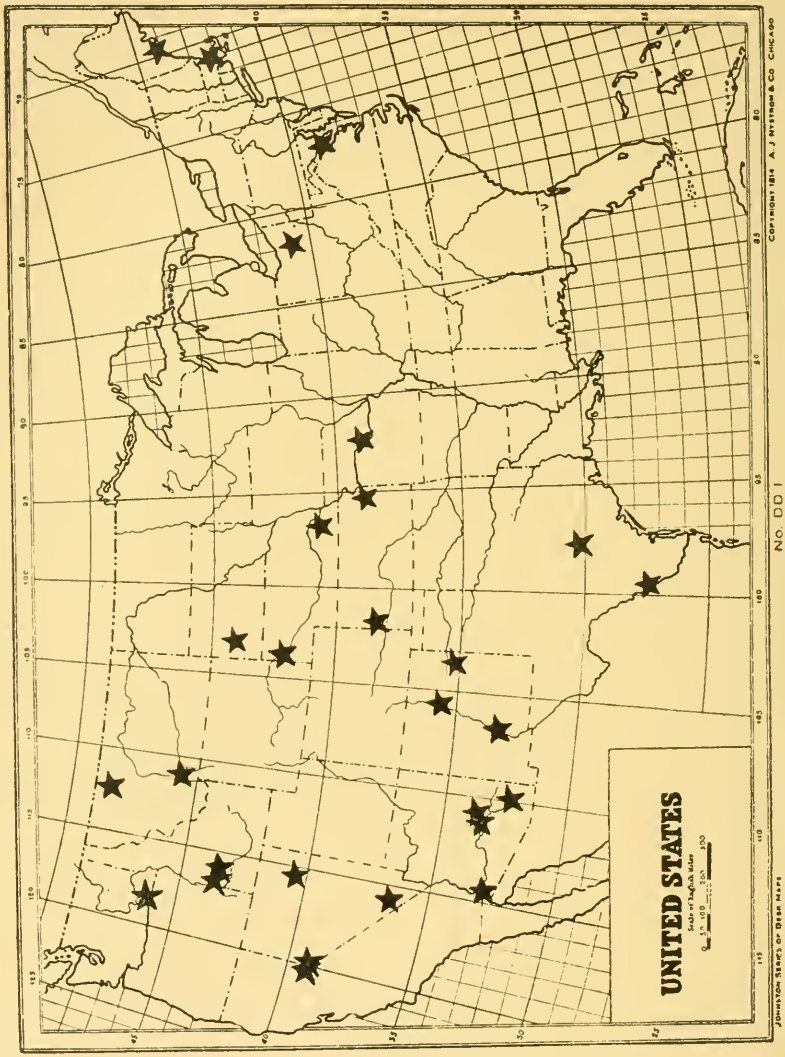
The chert graves mark the level of pre-glacial drainage. This at Atchison is at least twenty-five or thirty feet lower than the corresponding level in the Kansas river valley near Linwood, which indicates that Atchison was in the valley of a different master stream, presumably one which was a predecessor of the Platte of Nebraska, and of the Grand river, Missouri. Traces of its trough seem to have been found near Conception and Stanbury, Mo.

The advance of the Kansan ice sheet from Des Moines river valley southwest dammed the Platte-Grand river near Stanbury, causing a temporary lake or lakes in the valleys of that and of its tributaries, including that at Atchison. The water rose till it flowed over the divide south into the Kansas valley, presumably along the line of the present Missouri there.

This seems corroborated by the occurrence of a cobble and boulder deposit at Weston, Mo., and south, about 140 feet above the present Missouri. This, when discovered over twenty years ago, was thought to indicate rapids, very like such as this explanation would imply.

In frankness it should be acknowledged that similar lacustrine beds have not yet been found along the Nemaha, Nebraska, and Wolf creek, Kansas, as we should expect. Perhaps another twenty years may clear up the discrepancy.

March 23, 1918.



Map of the United States showing evaporation stations.

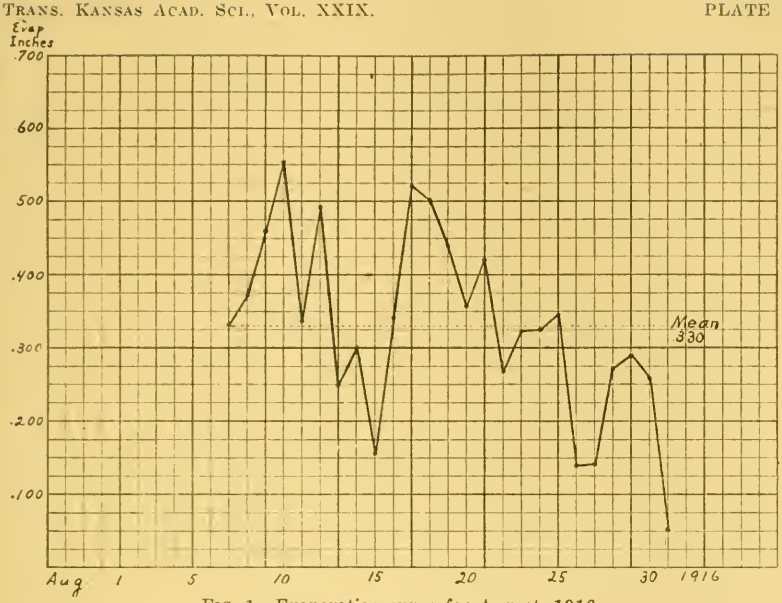


FIG. 1. Evaporation curve for August, 1916.

PLATE III.

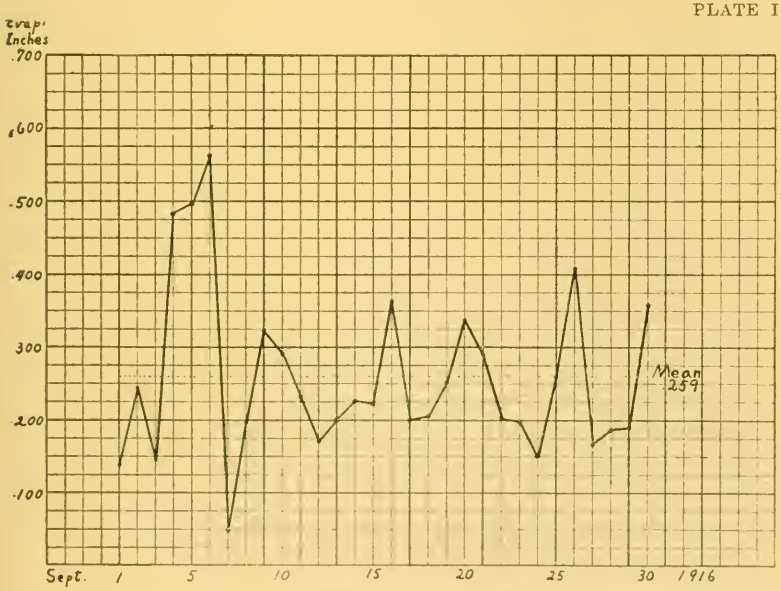


FIG. 2. Evaporation curve for September, 1916.

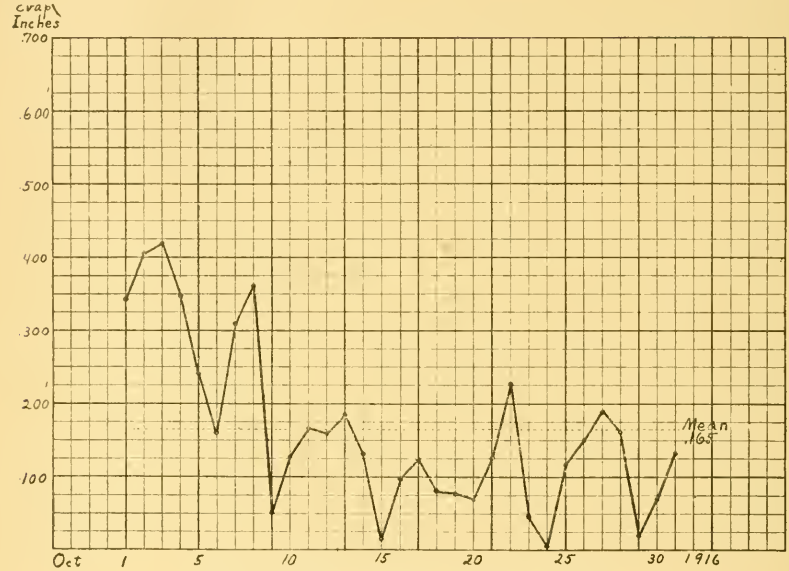


FIG. 3. Evaporation curve for October, 1916.

PLATE V.

FIG. 4. Evaporation curve for November, 1916.

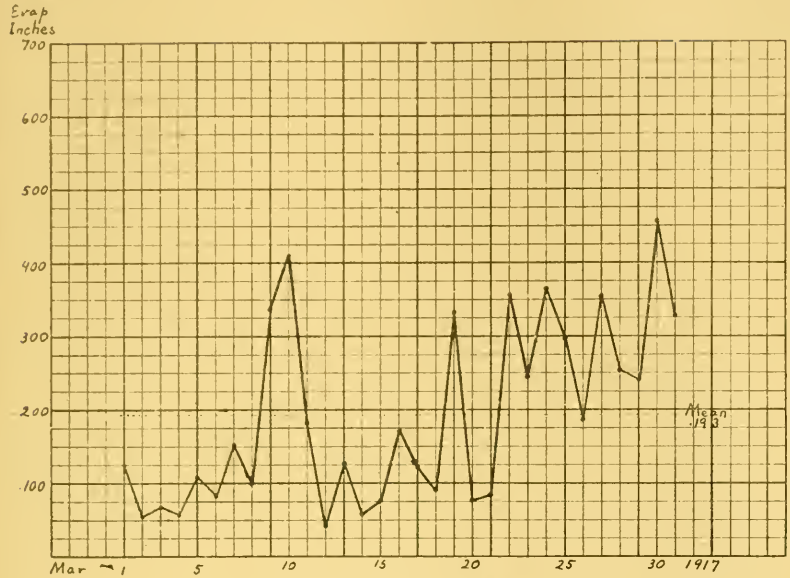


FIG. 5. Evaporation curve for March, 1917.

PLATE VII.

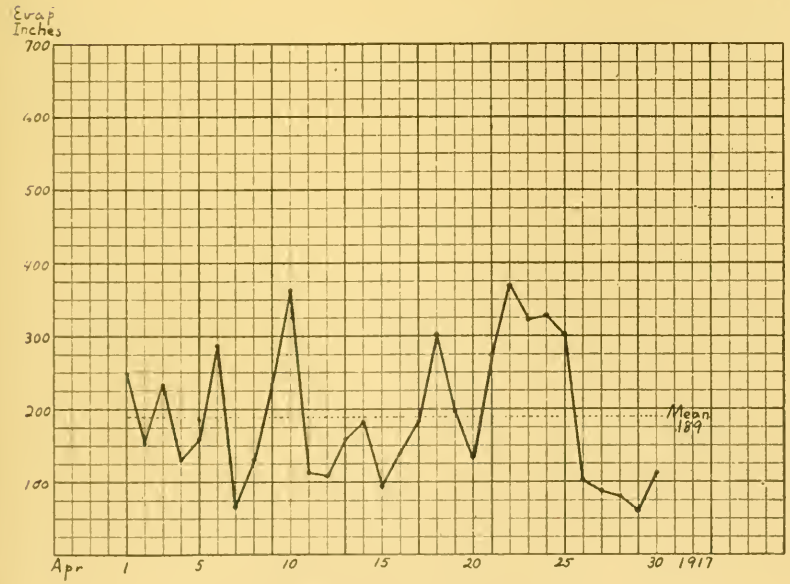


FIG. 6. Evaporation curve for April, 1917.

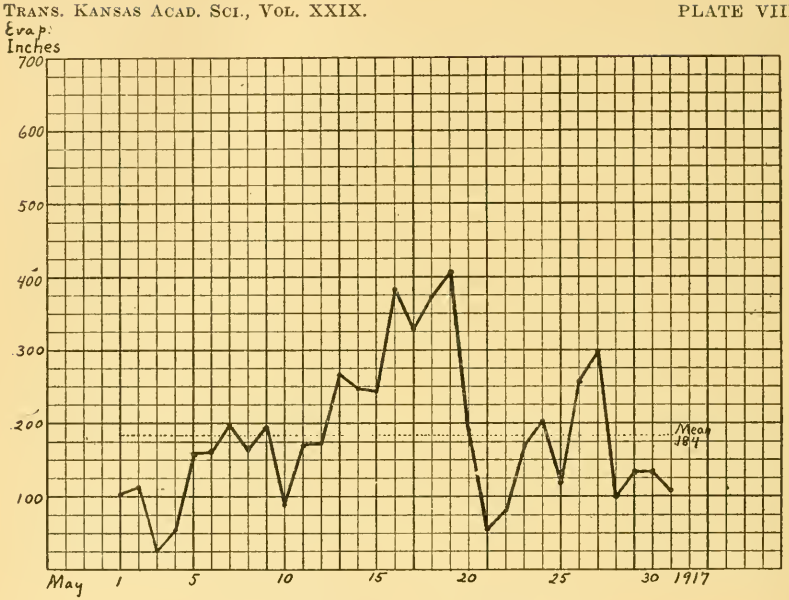


FIG. 7. Evaporation curve for May, 1917.

PLATE IX.

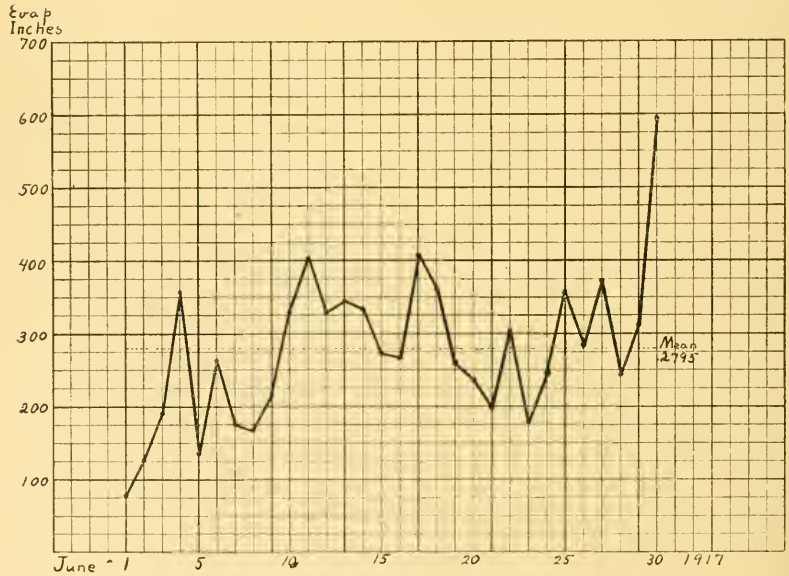


FIG. 8. Evaporation curve for June, 1917.

FIG. 9. Evaporation curve for July, 1917.

PLATE XI.

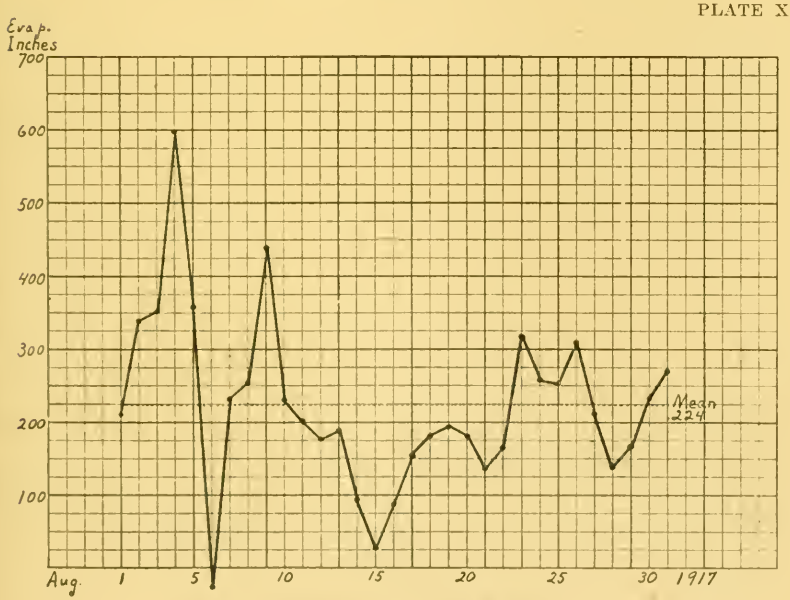


FIG. 10. Evaporation curve for August, 1917.

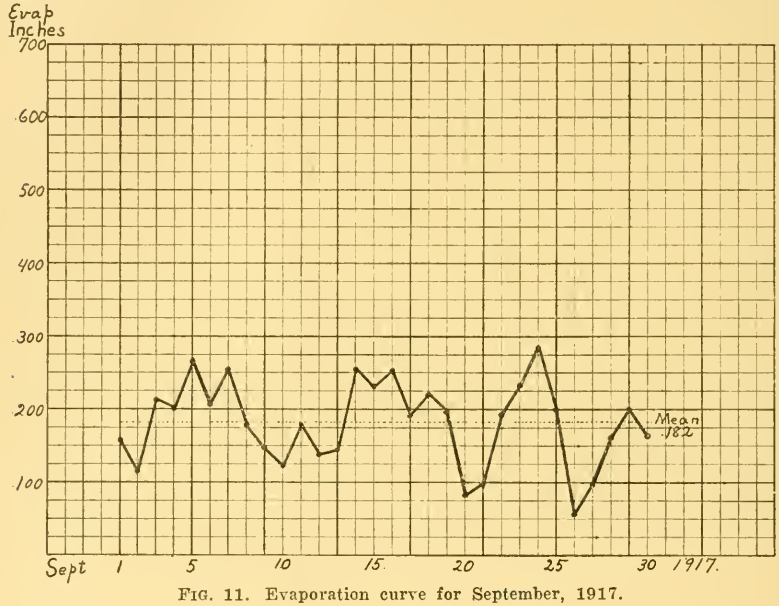


FIG. 11. Evaporation curve for September, 1917.

PLATE XIII.

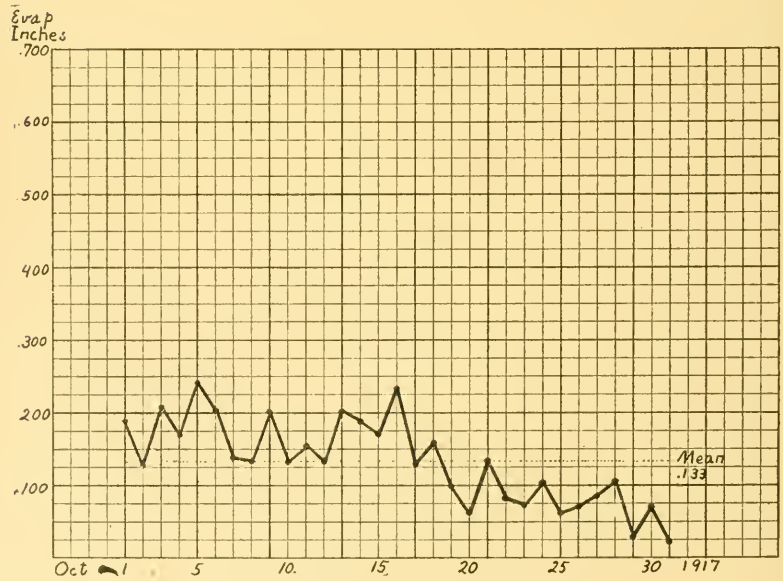


FIG. 12. Evaporation curve for October, 1917.

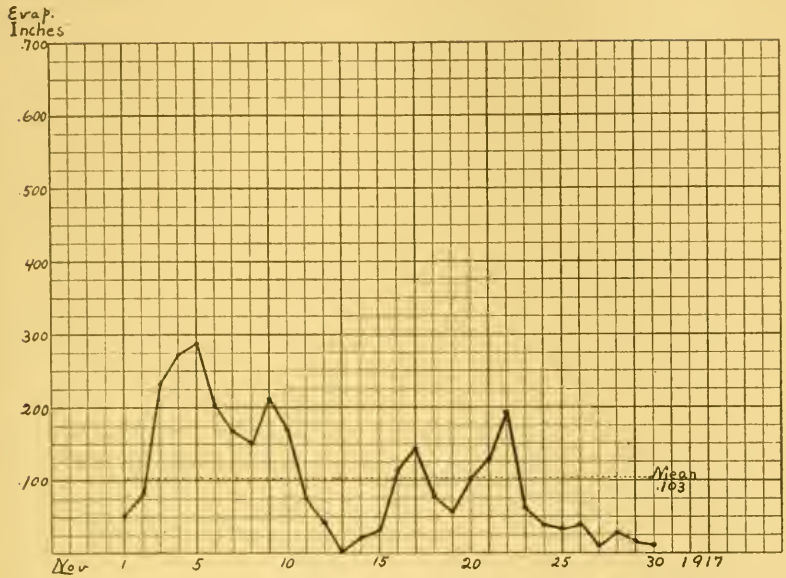


FIG. 13. Evaporation curve for November, 1917.

PLATE XV.

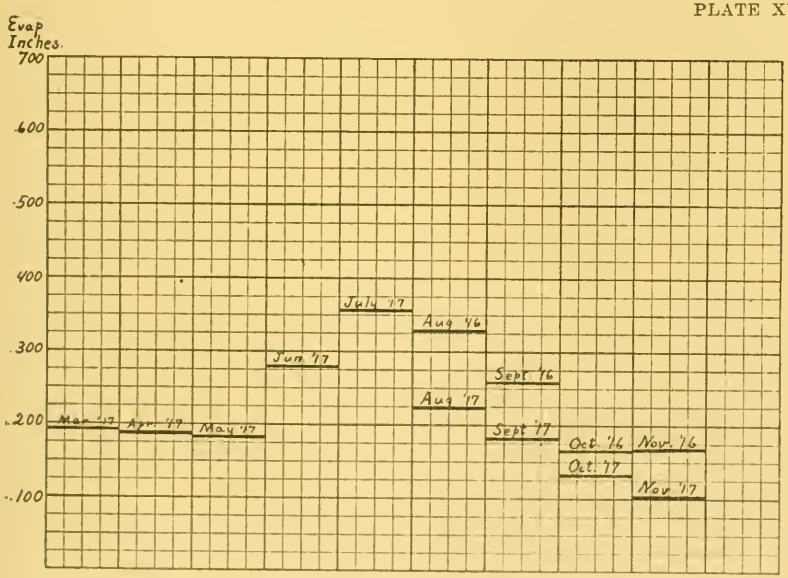


FIG. 14. Summary of evaporation data for 1916-'17.

Evaporation in Kansas.

Charles A. Shull, University of Kansas.

The state of Kansas, with its eastern boundary touching the Missouri river valley, and its western boundary lying in the midst of an area once popularly known as the great American desert, lies in an important climatic tension zone of the United States.

Eastern Kansas has an average annual rainfall of 35.25 inches, based upon thirty-one years of observation. During the same period the western division of the state has had an average rainfall of only 19.19 inches. And the central portion is just between, with an average of 26.24 inches per year. This difference in rainfall, connected directly, as it must be, with differences in relative humidity and evaporation intensity of the atmosphere, is one of the dominant climatic factors which determine the character of the native vegetation of the state; and the native plants of eastern and western Kansas are as widely different as one might expect from the difference in annual precipitation.

Measured in terms of crop production, a 19 to 35 inch rainfall, if properly distributed through the growing season, and utilized only by the crop growing on the land (a condition impossible of realization, of course), is sufficient for the production of from 60 to 105 bushels of wheat per acre. This estimate is based upon a water requirement for wheat of 500 pounds of water for each pound of dry matter produced, and assumes that grain and straw are produced in the proportion of two pounds of grain to three pounds of dry straw.

What becomes of the rainfall is therefore a problem of great interest in this great agricultural center of North America, where we think we do well if we average 25 bushels of wheat to the acre. Very frequently it happens that distribution of the rainfall is not favorable for maximum plant growth, and lack of moisture more often than any other condition becomes a limiting factor in crop production.

Of course, everyone knows that part of the rainfall is lost as run-off water before it has a chance to penetrate the soil. But a considerable part of the water does soak into the ground and becomes a part of the great subsurface reservoir of water which fills our wells, forms the source of the waters found in our permanent drainage systems, and furnishes the supply of moisture to the roots of growing plants. A third portion of the water evaporates from the soil surface, and from the leaf surfaces of vegetation. It is this loss which becomes serious when dry weather is prolonged, and the efforts of the farmer must be directed toward reducing direct soil evaporation to a minimum. Whatever loss occurs from the soil should always be confined, so far as possible, to the transpiration of living plants, if maximum yield is to be obtained.

Just how much water evaporates from the soil itself during a growing season is not known. It must depend on many factors, and vary greatly with soil type, configuration of the surface, methods of culture, climatic conditions, etc. But it would be of vital interest to know how much water goes out of our fields on days when atmospheric evaporation in-

tensity reaches its maximum. Unfortunately, there is no simple means of determining the amount of water lost from the soil day by day as a drouth proceeds. But we can measure the evaporating power of the atmosphere by measuring the actual work accomplished by the climatic factors causing evaporation.

Although the weather bureau has been in operation twenty-eight years, it is only recently that it has become properly interested in the evaporating power of the air as a factor in crop production and weather conditions in general. While a good many observations of various kinds are on record, the conditions under which the observations have been taken are so diverse that comparison of one locality directly with another is entirely out of question. In order to secure comparable data it was necessary to standardize the methods of taking observations. This has been brought about by the establishment recently of what are known as Standard Class A Evaporation stations in various localities, principally in the arid and semi-arid regions of the United States.

The Standard Class A station is constructed according to specifications furnished by the government, and consists of an evaporation pan four feet in diameter and ten inches deep, which is filled with water to a depth of seven or eight inches, and freely exposed to air and sunlight. A round brass cylinder called a still well sits in this pan of water and protects the water surface within it from being ruffled by the wind. This makes accurate readings possible. An accurate measuring instrument known as a hook gage is set on top of this well, and the level of the water in the pan is measured every day at a certain hour. The gage is constructed to read to the thousandth of an inch. In addition to the pan there is a rain gage to correct the readings of the level in case of precipitation, an anemometer to measure the wind flow across the surface of the pan, and a pair of thermometers to give the daily temperature range. All of these instruments are arranged according to a standard plan, and enclosed by a standardized net wire fence designed to offer little obstruction to light and air currents. By having every feature standardized every station is as near like all the rest as it can be made, and the readings from different stations can be compared directly. The first of these stations to be established was the Mitchell, Neb., station, which began observations in April, 1911, under the reclamation service. But in 1915, a model Class A station was established at the American University, Washington, D. C., which began its observations on April 18, 1915. Two other stations were established in 1915, one at Gardiner, Maine, and one at the Roosevelt dam in Arizona.

During the meeting of the Botanical Society of America held at Columbus, O., in December, 1915, a public announcement was made that the government had decided to attack the evaporation problem in earnest, and expected to establish a number of stations in advantageous locations. During 1916 twenty-five stations were established, and two were added in 1917. On January 1, 1918, therefore, there were thirty stations on the continental United States, and one at San Juan, Porto Rico. The map shown on plate I gives the locations of all active stations except San Juan.

Two of the stations were located in Kansas, one at Lawrence, under the auspices of the botany department of the University of Kansas, and one at Tribune, under the auspices of the Kansas State Agricultural College. The Lawrence station began its readings on August 7, 1916, and the Tribune station on August 16, 1916, in the midst of the serious drouth of that year.

The data which have been accumulated during the last two years are yet too meager to permit of any generalizations, but the mere facts have proved to be so interesting that they deserve to be made public.

The evaporation day by day has been plotted in the form of curves for the thirteen months during which observations have been possible. The winter months are omitted, of course, because the freezing of the water would endanger the pan and still well, and would make accurate readings impossible. The curves are shown on plates II to XIV.

These curves are very irregular, due to rapidly changing conditions of temperature, wind velocity, and relative humidity. The high points are often associated with high temperature, or brisk winds, or both in extreme cases. Unfortunately relative humidity data are not collected by these stations. The low points correspond to periods of rainfall, or low temperature, or light winds, or combinations of these conditions.

While each of the curves presents certain points of interest, the most striking one is plate X, for July, 1917, which illustrates the development of serious drouth conditions. The spring rains ceased on June 5, several weeks earlier than usual, and thereafter rainfall occurred as mere traces, or in insignificant amounts until August 6. About the middle of July (13-15), there were several small rains, following which the evaporation increased steadily to the end of the month, reaching on July 30 the highest daily rate ever recorded at the station, .709 inch. The maximum temperature was above 100° every day for the last six days preceding the 30th, and the wind velocity was high and constantly increasing during the last four days of this period. This climax to the long dry period came very near to being ruinous to crops, and would have been exceedingly destructive if copious rains had not fallen at the end of the first week in August.

It is interesting to note that the average daily evaporation during the drouth of August, 1916, was .330 inch per day, and the average daily evaporation for the drouth of July, 1917, was .357 inch per day. Perhaps it is not going too far to say that whenever the evaporation reaches an average of about .350 inch per day for a week or two at a time, drouth conditions are rapidly approached in eastern Kansas. The evaporation will not reach this level and maintain it until the weather has been dry for some time, and the soil has become too dry to contribute much to the humidity of the atmosphere. As long as the soil has a good supply of moisture near the surface, the evaporation does not reach the drouth level continuously, even though there is no rainfall.

A comparison of the evaporation with rainfall month by month is most interesting. And the surprising thing about it is the almost constant excess of evaporation over rainfall. The rainfall exceeded evaporation in only two months out of the thirteen recorded, and one of these,

November, 1916, would not have shown an excess if the whole month had been recorded. The record was terminated by severe freezing weather on November 13, a few days after a heavy rainfall.

If we divide the evaporation for any month by the rainfall for that month, the quotient gives a number which is known as the monthly evaporation-rainfall ratio. The evaporation-rainfall ratio for the months so far recorded, including the parts of months in August and November, 1916, are shown in table 1.

TABLE 1.

Year.	Month.	Evaporation.	Rainfall.	Evaporation-rainfall Ratio.
1916.	August (25 days)	8.245	.99	8.33
	September	7.761	3.21	2.42
	October	5.128	3.82	1.34
	November (12 days)	2.012	3.03	.66
	Total, 1916	23.146	11.05	2.09
1917.	March	5.953	1.55	3.84
	April	5.681	3.39	1.68
	May	5.701	3.97	1.44
	June	8.385	2.11	3.97
	July	11.061	.50	22.12
	August	6.956	4.69	1.48
	September	5.445	5.70	.95
	October	4.114	1.37	3.00
	November	3.079	.02	153.95
	Total, 1917	56.378	23.30	2.42

The mean daily evaporation for each month is shown in plate XV. The annual curve of evaporation intensity indicated by these means are much more closely related to temperature and humidity than to wind velocity, for surface wind velocity is highest in spring and fall, when the vegetation offers least resistance to air flow, while the lowest average wind velocities occur in midsummer or later, when vegetation is at its maximum development. In March the surface velocity was about four times as great as in August and September, and in November it was about twice as great as in September.

Comparison of the evaporation in western Kansas with that in eastern Kansas can be made as yet only in a fragmentary way, owing to the incompleteness of the records from the Tribune station. Only four complete monthly records have been made at Tribune, and the comparative data for these months at Lawrence and Tribune are shown in table 2.

TABLE 2.

Year.	Month.	Tribune.	Lawrence.	Difference.
1916.	September	9.347	7.761	1.586
1917.	April	6.880	5.681	1.199
	May	7.689	5.701	1.988
	September	8.494	5.445	3.049

From this table it is seen that the evaporation is from one to three inches per month greater in the western part of the state than in the eastern part. During a season this would amount to perhaps eighteen inches. It seems fair to conclude that the evaporation intensity of the atmosphere is on the average about 25 per cent greater at Tribune than at Lawrence. At the same time the precipitation is 45 per cent less at Tribune than at Lawrence, based upon the average annual precipitation for the eastern and western divisions of the state.

If the evaporation from the open pan actually represented water loss from the soil, Kansas long ago would have been a hopeless desert, for the evaporation measured in this way will always be greatly in excess of precipitation. The season's evaporation would amount to almost 6,400 tons of water per acre, or for the whole state approximately 350 billion tons—enough to produce nearly a billion tons of dry forage, if it could all be evaporated through the leaves of plants.

It is not to be supposed, of course, that the data obtained enable us even to guess at the actual loss of water from the soil, for as soon as the top layer of the soil becomes dry it forms a protecting blanket against the effects of the dry atmosphere, especially if it is kept loose-textured and well-tilled. But we can, after a fashion, grasp the significance of the intense evaporating power of the air to the living plant. The leaves of plants contain a high percentage of water, and they are exposed freely to the drying power of the air, which is believed to be equivalent on an ordinary dry day to nearly a thousand atmospheres of force. That is, when an object is becoming air dry, the molecules of water are extracted from the substance at least with a force of about fourteen thousand pounds per square inch. All of the moisture lost by the plant under the influence of these tremendous atmospheric forces must be made good by the actively absorbing roots, and if they fail to keep up with the drying process, wilting must occur. If the failure is by a narrow margin, wilting is only temporary, but even this greatly reduces plant production, while if the failure is severe, permanent wilting and death ensue.

One of the most important problems just ahead, therefore, is to determine the relation of evaporation from the standard pan to evaporation from the soil. On a day when the evaporation from the pan reaches .5 inch, how much drier does the soil become at a depth of six inches, or eighteen inches, where the mass of plant roots are located? And when we have a whole month of dry weather, how rapidly is the soil water depleted? What influence has soil type on the rate of water loss? What difference is there in the rate of water loss from fields of corn, wheat, etc., and on fallow land? These problems involve many complex factors, and may be very difficult to solve. But during the coming season it is hoped that a study can be made of several selected localities in Douglas county, with the purpose of determining the relation of atmospheric evaporation intensity, as measured by the Standard Class A Evaporation station, to the rate of disappearance of water from the soil itself. Such a study, aside from its scientific interest, should be of considerable practical importance.

Physoderma (zeæ-maydis?) in Kansas.

L. E. Melchers.

The writer collected specimens of *Physoderma* (*zeæ-maydis?*) on Zea mays at Manhattan, Kan., in October, 1915, in a field of corn which was being used for experimental purposes. Although it was strongly suspected that the fungus was *Physoderma*, it was not definitely determined until sometime later. Comparing this date of collection with that of other collections made up to that time in the United States, it appears that the discovery of this fungus in 1915 made the report the third in the United States. Since then, however, it has been located in numerous other states, particularly since the United States department of agriculture began its survey of this disease in 1917.

How long *Physoderma* has been in Kansas is not known, but the writer believes probably prior to 1913. Its presence in traces could easily escape attention. Its appearance in 1915 attracted notice and numerous collections were made. No specimens were found in 1916, but in 1917 it was again found and collected. It appeared in very limited quantities, at this time in May, in the vicinity of Manhattan, when a few specimens were collected. In October considerable specimens were located in the vicinity of Manhattan. Prof. G. W. Wilson visited Manhattan in October of 1917, and at that time was connected with a survey of this fungus in the employ of the United States Department of Agriculture. The writer is indebted to him for much of the data furnished in 1917. Up to the present date, *Physoderma* has been located in Kansas in the following places: In the Neosho bottoms in the vicinity of Chetopa, particularly to the east in the river bottoms, considerable amounts were located, and this likewise holds true for the Iola region. A trace was found at Fort Scott. It also occurred in slight amounts at Garnett, Ottawa and Marysville. At the latter place, one field contained considerable of the fungus. In Manhattan, the percentage ran higher than any place in the state as far as known. Here it did not only occur on the leaves and sheaths of the corn plant, but it was actually penetrating the nodes. The vicinities of Parsons, Independence, Lawrence and Emporia were visited, but no trace of the fungus was located.

The symptoms of the fungus in the early stage are rather difficult to distinguish from injury caused by Aphids. Blackened, irregular spots, or blotches may occur on the sheaths or main ribs of the leaves of the corn plant. Later in the development of the fungus, and as the host matures, these spots begin to rupture and expose a powdery, dark, reddish-brown mass of spores. The ruptures are irregular and may vary from a few to many millimeters in length. A shredded condition at the base of the leaves is not uncommon; in fact, this is one of the striking characteristics of the fungus. When the nodes of the corn plant are attacked and penetrated by this fungus, the infected regions show a more or less shrunken condition.

THE IMPORTANCE OF THIS FUNGUS IN KANSAS.

It is difficult to state of what economic importance this disease will prove to be in Kansas. In some of the southeastern states it is causing considerable damage. The important factors involved, as far as this state is concerned, are, that *Physoderma* occurs in Kansas, and indications are that it can live over as far north as this region. Further investigations of this disease in the state will be made.

In our scheme of classification, this fungus is placed in the order, *Chytridiales;* sub-order, *Mycochytridiineæ;* family, *Cladochytriaceæ*, along with such genera as *Urophlyctis, Cladochytrium*, etc.

Class. *Archemycetæ.*
Ord. *Chytridiales.*
Sub. ord. *Mycochytridiineæ.*
Fam. *Cladochytriaceæ.*
Genus. *Physoderma.*

Laboratory of Plant Pathology, Agricultural Experiment Station, Manhattan.

Plant Disease Report for Kansas, 1917.

L. E. Melchers, Plant Pathologist, Kansas State Agricultural College, Manhattan.

CEREAL DISEASES.

Bunt of Wheat. *Tilletia fœtens* B. & C. Among the wheat diseases occurring in 1917, bunt was given more attention than usual. This was made possible in connection with the seed survey situation of the state. The counties where bunt was located in greater or less quantities were Reno, Stafford, Rice, Pratt, Harper, Dickinson, Barber, Norton, Chase, McPherson and Sumner. The majority of fields that showed the presence of bunt contained from two to five per cent, but many showed as high as twenty-five per cent.

Loose Smut of Wheat. *Ustilago tritici* (Pers.) Jens. This smut is more commonly and widely distributed over the state than bunt, but always appears in much smaller quantities. Generally from a trace (less than one-fourth per cent) to one and one-half per cent loose smut can be found in the great majority of wheat fields in Kansas. Occasionally a field has been found to contain as high as twenty-five per cent infection, but this is rare.

Black Chaff and Stem Disease of Wheat. *Bacterial.* The disease here described seems to be causally bacterial, although further work is necessary to prove the entire life history of the disease in question. This disease was given its common name by the writer in 1915. It was under experimentation by the writer in 1914, but the first newspaper article was published in 1915. Since this disease has been under observation, it was the worst in 1915. At that time excessive rains and the humid atmosphere made it favorable for its maximum development. Apparently this trouble has been most conspicuous in this state, at least as far as the "neck," head and glume infection is concerned. The blackened areas on the "neck" of the wheat plants, together with the spots or stripes of

black on the glumes, make it conspicuous at heading time. A symptom more or less directly connected with the disease is the exuding of droplets from infected areas. Some seasons the seed of infected plants becomes shrivelled, but the extent of damage and the prevalence of this disease in Kansas seems quite dependent upon certain weather conditions. A bacterial trouble closely associated with this occurs on the foliage, but prior to the black chaff and stem disease symptoms on the wheat heads. Whether this is all one and the same disease is not definitely known. The black chaff and stem disease of wheat was observed in many places in the state in 1917, but was most abundant in Manhattan. Practically no loss was sustained in the fields where it occurred this year.

Stem Rust of Wheat. *Puccinia graminis tritici.* Only slight infections of stem rust were recorded in the state the past season. No fields showed more than a trace.

Leaf Rust of Wheat. *Puccinia triticina* Erikss. This was present everywhere on the leaves of the wheat crop at heading time. In many localities it did not appear in the fall of 1916.

Covered Smut of Barley. *Ustilago hordei* (Pers.) K. & S. This disease occurs quite consistently in most fields of barley, where seed treatment has not been given. The average per cent of this fungus in the field is about four.

Loose Smut of Barley. *Ustilago nuda* (Jens.) K. & S. This fungus is more abundant in the barley crop than the loose smut of wheat is in the wheat crop. The loose smut of barley is generally found in every barley field, the percentage running close to four per cent for an average.

Leaf Rust of Barley. *Puccinia simplex* Erikss. & Henn. This is the most uncommon of the cereal leaf rusts in the state. Generally small amounts can be found each season.

Loose Smut of Oats. *Ustilago avenæ* (Pers.) Jens. This disease is the most common of the oat diseases. It is very common to find eight per cent of the crop affected with loose smut. Since oat seed treatment is becoming more generally used, the losses are not as great as they formerly were.

Covered Smut of Oats. *Ustilago levis* K. & S. Magn. This smut likewise occurs in this state, but not as commonly as the loose smut. Both oats smuts can frequently be found in the same field.

Blade Blight of Oats. *Bacterial.* What seems to be a bacterial disease of oats was rather conspicuous the past season. Whether this is the same as the organism described by Manns[1] is not known. Distinct bacterial infections can be noticed. Sometimes this is accompanied by a reddish coloration of the foliage.

Leaf Rust of Oats. *Puccinia lolii avenæ* McAlpine. This rust was present in moderate amounts the past season. No damage to the crop was reported.

Rye. (*Bacterial disease.*) A conspicuous trouble was noticed on the rye crop the past season. Droplets of bacterial ooze were noticed on

[1] Manns, T. F. Ohio Bull 210, 1909.

plants in the field. These droplets were found exuding from all parts of the stems. No apparent injury occurred.

Leaf Rust of Rye. *Puccinia dispersa* Erikss. This leaf rust is very common in the state and was present in normal quantities the past season.

Kernel Smut of Sorghum. *Sphacelotheca sorghi* Lk. This smut is always present in Kansas in greater or less quantities. In many fields five per cent of the heads are affected and it is not unusual to find fields showing fifty per cent smutted.

Head Smut of Sorghum. *Sphacelotheca reiliana* Lk. The head smut of sorghum has been reported from several places in the state the past season. Although it has never been present in alarming quantities, the past season showed that under proper conditions it appears to live over in this region. Considerable head smut of sorghum was reported from Stockton. It has also been reported from Finney county.

Bacterial Sorghum Spot. *Bacillus sorghi.* Considerable leaf-spot of the sorghums is present every season. This has been said to be due to a bacterial trouble, but how much is due to other causes and factors is still an open question.

Corn Smut. *Ustilago zeæ* (Beck.) Ung. Corn smut was the most prevalent that it has been for years. It was not uncommon to find fields that showed as high as fifty and seventy-five per cent of smut. The yield was considerably reduced by the presence of so large an amount. Less smut occurred in the southern and eastern part of the corn belt, while more smut occurred in the east central part and northern region. In the vicinity of Manhattan anywhere from twenty-five to sixty per cent was found.

New Corn Disease. *Physoderma* (*zeæ-maydis?*). This fungus was first found by the writer in 1915, when it occurred in considerable quantities at Manhattan. It causes reddish-brown or chocolate ruptures in the later stages of development, but when first noticed it produces blackened, small spots or blotches, not unlike the injury caused by aphids. The main ribs of the leaves, sheaths and nodes may be attacked. A shredded condition at the base of the leaves is a common symptom of this fungus. *Physoderma zeæ-maydis* was located in the following places the past season: At Manhattan it was the most prevalent of any place visited in the state. It also occurred in lesser quantities in fields around Chetopa and Iola. A trace was found at Garnett, Ottawa and Marysville.

Rust of Maize. *Puccinia sorghi* Schw. This is generally present every year. The past season it seemed to be more prevalent than usual.

Stem Rust of Timothy. *Puccinia phlei-pratensis* Erikss. & Henn. A few reports were received of slight infections of timothy rust, but the amounts were very slight. In 1916, however, severe infection occurred in fields of timothy.

Root Rot of Alfalfa. *Rhizoctonia violaceæ.* This root disease of alfalfa is quite serious in many alfalfa fields over the state, particularly if fields have been in alfalfa too long. Plants die out in spots, the disease spreading from year to year by carrying over on decaying roots. Plants affected turn yellow, wilt and gradually die. If the roots are examined,

a violet colored mass of mycelium will be found, after which the disease has been named "violet root rot."

Leaf-spot of Alfalfa. *Pleosphærulina briosiana* Pol. This is the disease reported by Melchers[1] in 1915. It occurred in small quantities the past season. Causes greyish-brown, irregular spots on the foliage.

Leaf-spot or Blotch of Alfalfa. *Pyrenopeziza medicaginis* Fcl. This leaf-spot was described by the writer in 1915-'16 as *Phyllosticta medicaginis.*[2] It proved very prevalent during those years and considerable loss was sustained. It was not common, however, in 1917. This spot on alfalfa foliage is best described by calling it a "blotch" disease, rather that a leaf-spot. The affected leaves become more or less yellowish in color and the fruiting bodies are easily detected in the yellowish areas. No dead areas are caused, as is common in the leaf-spots, but the entire foliage assumes a sickly, sulphur-yellowish color or tinge. In severe cases the growth of affected plants is considerably impaired.

Alfalfa Stem Disease. *Phoma sp.* This disease has been observed since 1915, and indications are that it has been in the state a good many years. The stems of the alfalfa plant show dark areas, which in severe cases cause more or less drying of the stalks.

VEGETABLE DISEASES.

Black Scurf of Potato. *Rhizoctonia solani* Kühn. This disease was very severe in Kansas in 1917. Many fields contained from one to twenty-five per cent. The infection is carried on the seed, which if not given a seed treatment before planting will kill the young sprouts.

Black Leg of Potato. *Bacillus phytophthorus* Appel. This disease is found in many fields in the state, but very frequently a *Fusarium* infection is associated with it. Young sprouts die at the base, where a soft rot of the stems occurs. Infected seed is the source of the trouble.

Tip Burn of Potato. *Non-parasitic.* This malady and sun scald are two of the worst troubles affecting potatoes in Kansas. The lack of soil moisture at the proper time, together with transpiration factors in the plant, are apparently responsible for this injury. Potato vines may burn entirely brown and dry before the crop is mature. Tip burn is generally confined to the margins of the leaves, which turn brown, dry, and are materially injured. This is most common during the dry weather in July.

Sweet Potato Stem-rot. *Fusarium batatis* Wolb. and *Fusarium hyperoxysporum* This disease, which may be caused by either of the *Fusaria* species, is common in the state. Most sweet potato fields have more or less of this disease in them. The foliage of the diseased plant turns yellowish and wilts. Infection enters through the roots and blackens the vascular system. The potatoes show the disease at the place of attachment. By making cross sections of the roots, the blackened streaks of infection can be seen.

Sweet Potato Soil Rot or "Pox" Disease. *Cytospora batata* Elliot. This disease was reported for the first time this season in the state. It

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[1] Melchers, L. E. A New Alfalfa Leaf-spot in America. Science, n. s., 42:536-537, 1915.

[2] Melchers, L. E. Plant Diseases Affecting Alfalfa. Rpt. Kans. State Board of Agri., 35:339-353.

has probably been here for two or three years and in all probability came here with infected seed. It causes pits or "pox" spots in the tubers, which disfigure them for market purposes. These injuries are produced by one of the slime mold organisms, *Cytospora batata.* The "pox" injuries also afford opportunity for the entrance of secondary infections of black rot of sweet potato. Many specimens showed a combined infection of these diseases.

Bean Anthracnose. *Colletotrichum lindemuthianum* (Sacc. & Magn.) Scribn. On account of the large acreage of beans grown the past season, considerable anthracnose appeared, particularly since most of the seed was imported. Young plants showed lesions when only four or five inches tall, and as a result many plants died. The latter part of the season was not favorable for anthracnose development, and not very much evidence was found on the bean pods.

Cabbage Yellows. *Fusarium conglutians* Wr. Only one report of this disease was called to the writer's notice. The plants were doing poorly, turning yellow, and the leaves were dropping.

Black Spot of Pepper. *Alternaria sp.* In 1915 the writer noticed, for the first time, a serious trouble attacking various varieties of peppers. This disease has been present every season since. It causes large black sunken areas or spots on the fruit. The fruit is destroyed for commercial purposes. The disease seems to be a combination of sun scald and fungus injury. There is a marked difference in varietal susceptibility, the Chili peppers not being susceptible.

Blossom Drop of Tomato. *Non-parasitic.* The cause of this malady has not been determined. It is present in the state in greater or less amounts every season. Tomato plants are apparently vigorous and appear to be thrifty, but the blossoms drop. Many causes have been proposed but the real factors are problematical. Considerable loss of fruit is the result.

Blossom-end-rot of Tomato. *Cause not known.* Very little of this disease was present last season. The wet weather in August may have been responsible for this. In this disease the blossom-end of the fruit turns black and decays or appears water-soaked. The disease appears when the tomatoes are about half grown. Affected fruit cannot be used.

Bacterial Wilt of Cucumber. *Bacillus tracheiphilus* E. Smith. This disease is most common on the cucumbers, but occasionally occurs on melons in this state. Plants may be affected when only a few inches tall, or they may develop to the runner stage and then wilt. The bacteria are transmitted for the main part by insects, particularly the striped cucumber beetle, which attack the plants.

FRUIT DISEASES.

Anthracnose of Melons. *Colletotrichum lagenarium* (Pass.) Ell. & Hals. This occurs to a greater or less extent every season on the watermelons, and to a lesser extent on muskmelons. The foliage is not so often attacked.

Raspberry Anthracnose. *Glœosporium venetum* Speg. This disease is rather common in the state wherever these brambles are grown. Attacks the canes, causing grayish spots, which are somewhat roughened. In

severe cases it causes the canes to crack. Foliage shows small leaf-spots.

Orange Leaf Rust of Blackberry. *Gymnoconia interstitialis* (Schl.) Lagh. This disease is found more or less every season. Attacks both blackberry and raspberry. Whole plants may be destroyed. The orange-colored rust spores crop out from the leaves and young shoots, which are infected.

Strawberry Leaf-spot. *Mycosphærella fragariæ* (Schweinitz) Lindau. Commonly found wherever these berries are grown. Causes small, deep purple, or red spots, generally first observed on the upper surface of the leaves. No particular damage results to the berry crop in this state.

Apple Blotch. *Phyllosticta solitaria* E. & E. This disease was present in average amounts. Occurs in every county in the state where apples are grown. Attacks the fruit, leaves and twigs.

Apple Bitter Rot. *Glomerella cingulata* (Stoneman) Sh. and von Sch. This disease was present in very small quantities along the Missouri border.

Illinois or Apple Blister Canker. *Nummularia discreta* Tul. This disease is by far the worst of any of the apple diseases in the state. Most common in run-down orchards. Occurs in every county where apples are grown extensively. Attacks only the woody parts of the tree and is confined to limbs one inch or larger in diameter.

Black Rot of Apple. *Physalospora cydoniæ* Arnaud. This disease occurs on fruit, foliage and limbs of the apple tree in Kansas. It is most common on fruit that has already been injured mechanically or through insect puncture. It is quite common on the foliage, where the frog-eye markings are quite prominent. The cankers of black rot are generally found where the wood has been injured by sun injury or otherwise. Such cankers are a source of infection for a number of seasons.

Apple Scab. *Venturia inæqualis* (Cooke) Winter. This fungus was less conspicuous in 1917 than in 1916. Its presence on fruit and foliage was not very prominent, not even in unsprayed orchards. Climatic conditions are not generally favorable for its development in this state.

Spur Blight of Apples. *Bacillus amylovorus* (Burr.) Trev. There was less spur blight of apples than usual the past season. Pear blight was present in usual amounts.

Blossom-end-rot of Apples. *Alternaria sp.* This disease was observed for the first time the past season. The blossom-end of the apple turns black, involving an area generally of one-half inch. The symptoms appear as though they could be caused by spray burn. Frequently small radiating cracks go out from the blackened areas. Black rot was found associated with this injury sometimes, but the cause of the primary injury is not *Physalospora cydoniæ* Arnaud. An *Alternaria* may be the primary cause, but this is not definitely known.

Cedar Apple Rust. *Gymnosporangium juniperi-virginianæ* Schw. This fungus is present every season in regions where both the apples and red cedar are grown. It is rather rare to find the fruit of the apple affected in this state. The foliage of the apple tree is the only part of the host attacked.

Brown Rot of Stone Fruits. *Sclerotinia cinerea* (Bon.) Schrot. This disease was only reported on plums the past season, but no doubt it occurred on cherries and peaches where there was a crop. Little twig injury has ever been observed and cankers on peach are rare.

Cherry Fruit Disease. *Bacterial.* Two reports came to the writer's attention the past season, where a new cherry fruit trouble seemed to be causing damage. The fruit showed indications of a bacterial infection, being attacked when about half grown. The cultures obtained, however, did not give positive results upon inoculation. Further work is necescary to prove its real cause.

Peach Leaf Curl. *Exoascus deformans* (Berk.) Fckl. This was present in very limited quantities the past season on the foliage of the peach tree. In this state only the foliage is attacked.

Red Cedar Blight. *Phoma sp.* This made its appearance in 1916 for the first time in the cold frames of the nursery. Seedlings began dying at the tips. The symptom was a regular blight and frequently involved the entire seedling.

WINTER INJURY TO PLANTS.

As a whole, considerable winter injury occurred to evergreens and deciduous trees over the state. It was particularly serious among the cedars in many cases, and hedges and trees were severely injured. Later in the season the plants outgrew this. The injury was prevalent in many cases on the north or northwest exposure.

Agricultural Experiment Station, Manhattan.

Water Relations of Corn and the Sorghums.

EDWIN C. MILLER.

The statement that the sorghum plants produce a crop of both forage and grain under conditions that are prohibitive to the growth and maturity of the corn plant, needs no explanation to a Kansas audience. That the sorghums have been one of the most potent factors in the development of dry farming in the central and southern portion of the great plains during the past fifteen years, is unquestionable.

A knowledge of the characters that enable these plants to grow and develop under the conditions of the great plains, would be of value to those engaged in the breeding and development of plants for the semi-arid regions. In view of these facts, a series of investigations have been conducted during the past four years, in order to determine the fundamental characteristics possessed by the sorghum plants, which enable them to withstand severe climatic conditions better than the corn plant. These experiments were carried on at the State Branch Experiment Station at Garden City. This station is well suited for an experiment of this type, since the severity of the climatic conditions during the summer months is exceeded little or not at all by any other point in the great plains area. It is intended in this paper simply to summarize the results that have thus far been obtained in these experiments.

ROOT SYSTEMS.

The root systems of Pride of Saline corn, Blackhull kafir and Dwarf milo plants, which were grown in alternate rows, were isolated in the field at four stages of growth in 1914, and at three stages of growth in 1915. All told, the root systems of thirty-three plants were isolated and studied. It was found that for a given stage of growth each plant possessed the same number of primary roots, and that the general extent of these roots in both a horizontal and vertical direction was the same for all three plants. The maximum depth of root penetration for mature Dwarf milo, Blackhull kafir and corn was found to be six feet for both the years 1914 and 1915. It was found that Blackhull kafir and Dwarf milo possessed approximately twice as many secondary roots per unit or primary root as did the corn plant. This was true, not only for both years, but also for all stages of the root systems examined. Both the primary and secondary roots of the sorghums were found to be more fibrous than those of the corn plant.

LEAF AREA.

The average leaf areas of five representative plants of corn, Blackhull kafir and Dwarf milo, were obtained at stages when the plants were four, six, eight and ten weeks of age. The last stage examined showed that the plants had completed their full leaf development. In all stages of growth the corn plant was found to have the greatest leaf area. Taking the stages of growth in order, one finds that the leaf area of the corn plant was 1.7, 2.0, 2.2 and 2.3 times the leaf area of Dwarf milo, and 1.6, 1.9, 1.5 and 1.5 times that of Blackhull kafir.

VARIATION OF WATER AND DRY MATTER IN THE LEAVES.

The variation of the water and dry matter in the leaves of corn and the sorghums was determined by nine experiments in 1914, two in 1915 and four in 1916. These experiments were conducted with plants of Pride of Saline corn, Blackhull kafir and Dwarf milo, which were grown in the field either in a series of plots, or in alternate rows on the same plot. Four of the experiments in 1914 extended only through the daylight hours, but all the other experiments ranged in length from twenty-four to forty-eight hours. In these experiments the water and dry matter in the leaves were determined every two hours during twenty-two days and ten nights. The amount of water in the leaves of milo was found to be much lower at all times of the day and night than that of either corn or kafir leaves at a like stage of development, while the average water content of the corn and kafir leaves at the same age was practically the same. The water content of the leaves of corn, kafir and milo averaged 118, 129, 107 gms., respectively, for each square meter of leaf during the day periods, and taken in the same order, 128, 133, and 116 gms. for the night periods. The average range between the maximum water content of the leaves during the night and the minimum amount during the day was 24 gms. for corn, 26 gms. for kafir and 22 gms. for milo.

The dry weight of a given area of milo leaf was always found to be greater than an equal area of either corn or kafir leaves at the same

stage of development. The average dry weight of a square meter of leaf for all the observations made was 48 gms. for corn, 53 gms. for kafir and 56 gms. for milo. The average difference between the minimum and maximum amount of dry matter in the leaves for each square meter of leaf from 7 a. m. to 7 p. m. was 4.5 and 8.0 gms., respectively, for corn, kafir and milo. The increase in dry matter began at daybreak, and the maximum amount of dry matter in the leaves occurred in most cases between 2 and 5 p. m. The rate of increase of the dry matter in the leaves during the portion of the day when the climatic conditions were severe was much higher for milo than for either corn or kafir.

COMPARATIVE TRANSPIRATION.

Five experiments were conducted in 1916 and eight in 1917 to determine the relative transpirations of corn and the sorghums. Pride of Saline corn, Blackhull kafir, Dwarf Blackhull kafir and Dwarf milo were used in 1916, and in 1917, in addition to these, Freed's White Dent corn, Sherrod's White Dent corn, Freed's sorgo, Red Amber sorgo and feterita were used. The plants were grown in large galvanized iron cans with a capacity of about 120 kilos of soil. The soil used in 1916 had a water content of 18 per cent and a wilting coefficient of 11.1, while the moisture content of the soil used in 1917 was 22 per cent and had a wilting coefficient of 15.1.

The transpiration was determined in most of the experiments every two hours from 7 a. m. to 7 p. m. Each experiment extended through two or three days. In 1916 the cans were placed in the open on the surface of the ground, but in 1917 they were placed in a pit in the center of a plot that was planted to corn. The pit was of such a depth that the top of the cans were on a level with the surface of the ground.

Blackhull kafir and Dwarf Blackhull kafir always had the lowest rate of transpiration per unit of leaf surface in the experiments in which these plants were used. All the varieties of corn used always transpired more water per plant during any given period than did any of the sorghums. Their rate of transpiration per unit of leaf surface was, with the exception of the kafirs, always lower than that of the sorghums. The rate of transpiration per unit of leaf surface for feterita, Dwarf milo, Freed's sorgo and Red Amber sorgo was much higher than that of the corn plant under the same conditions. The difference in the transpiration rate of corn and the sorghums was more marked when the plants had reached their full leaf development and the difference in leaf surface of these plants had reached a maximum. The difference in the transpiration rate per unit of leaf surface was always more evident under severe climatic conditions than under conditions where the evaporation was low.

SUMMARY.

In comparing the corn and sorghum plants, it will be seen that in all stages of their growth the sorghum plants have a primary root system that is just as extensive as that of the corn plant. In addition, the sorghums possess twice as many secondary roots as the corn at any stage of its growth. The leaf area of the corn plant at all stages of its growth is approximately twice as great as that of the sorghums.

The sorghum plants thus have the advantage over the corn plant under any climatic condition that would tend to bring about a loss of water from these plants. The sorghums have, in the first place, as compared to the corn plant, only one-half the leaf surface exposed for the evaporation of water; and in the second place, they have a root system which, judging from the number of secondary roots, would be twice as efficient in the absorption of water from the soil. As a result of this advantage the sorghum plants are able to absorb water from the soil as rapidly as the evaporating power of the air demands its removal from the leaves. The corn plant, on the other hand, is not capable of supplying its large extent of leaf surface with a sufficient amount of water to satisfy the evaporating power of the air, and, as a result, its rate of transpiration per unit of leaf surface falls below what it would be if the needed amount of water were supplied, and is thus lower than that of the sorghums.

As a farther result of the water supply in the leaves, the sorghums can produce more dry matter for each unit of leaf area under severe climatic conditions than the corn plant.

Kansas State Agricultural College, Manhattan.

The Wamego Anticline.

J. W. Beede.

In examining the region west of Wamego an anticline fold or arch of considerable dimensions was found. It lies west of Wamego and Louisville and largely east of St. George. The outline of the apex of this fold is very difficult to determine on account of the rocks being deeply covered with loose glacial material, so that few rock exposures exist over the territory. However, along the Kansas river this material has been carried away sufficiently to reveal the surface strata. An occasional exposure and the dips of the starta in the region adjoining indicate fairly clearly the location of the axis, or top, of the dome.

The total extent of the field is very great, reaching from the vicinity of Manhattan on the west well toward St. Marys on the east, and a proportional distance toward Westmoreland on the north. However, the apex of the dome—the part of most importance—is fairly limited in extent. This central part would serve as the reservoir of all these great collecting grounds. The rim of this central part begins just east of St. George, extending north along the west side of sections 4, 33, 28 and 21, townships 9 and 10 south, range 9 east. From here it seems to swing eastward in a semicircular curve through section 10, the north side of sections 14, 13 and 18, then to the south across section 19 and the west side of 20, south through 29, 32, 5, 8 and 17 to the river.

The most important part of the fold probably is to be found in sections 1, 2, 11, 12, 13, 14 and the east half of 3, 10 and 15, township 10 south, range 10 east. The rocks of this dome have an elevation at the center of nearly 300 feet above their altitude at their extreme limits of the fold, thus furnishing a considerable relief and capacity for the collection of gas or oil, should these products occur in the rocks below.

There are perhaps three horizons, or beds, in which these substances might be expected to occur. The uppermost of these has been removed from the region under consideration, and is the upper Elmdale gas-bearing bed. The next is the one from which the gas occurs at Elmdale, reported to me to be 700 feet below the first. This would be some 600 to 650 feet below the river level. Another might occur at 1,000 or 1,200 feet below the surface. It is also possible that the basal Cherokee shales might prove productive, but this is very doubtful. The Cherokee shales are productive in eastern Kansas and Oklahoma.

I believe this field is worth a thorough test for the existence of these materials. It is too large for one or two wells to test it out thoroughly, unless by accident the first ones happen to hit the most favorable places.

Algæ of Kansas Reservoirs.[1]

JAMES BERNARD MCNAUGHT.

INTRODUCTION.

This report has been prepared with a two-fold purpose. First, it is intended to serve as an aid to the sanitary engineer by explaining the harmful effects of heavy growths of microorganisms in the city water reservoirs, and by describing the organisms causing trouble and the best methods for their eradication. Second, it is the first report of the survey of the algæ of Kansas by the University.

This survey was planned several years ago by Prof. W. C. Stevens and Dr. Grace M. Charles of the Department of Botany and Prof. C. C. Young and Miss Myrtle Greenfield of the Water and Sewage Laboratory of the State Board of Health. As a part of this plan, adapted especially to the need of the sanitary engineer, I began in 1915 to study the algæ of the surface water reservoirs of the cities of Kansas. Through the generosity of Mr. Young, I was provided with reference works and the standard conveniences for collecting the samples over the state, and for making the analyses.

In classifying the 110 species of algæ listed in this report, the following books were found most valuable. "Sylloge Algarum," by De Toni; "Minnesota Algæ, Vol. I," by Miss Tilden; Wolle's "Fresh-Water Algæ of the United States"; "The Green Algæ of North America," by Stokes; "The Algæ of the Fresh Waters of Connecticut," by Conn; "Synopsis des Diatomees de Belgique," by Van Heurick; and "Die Natürlichen Pflanzenfamilien," by Engler and Prantl.

The key adopted in this bulletin is based upon that given by Miss Tilden for the Myxophyceæ, F. S. Collins for the Heterokontæ and Chlorophyceæ, with the exception of the family Desmidiaceæ, where Stokes' classification is used. Shüt was the authority for the Bacillarieæ.

(I take this opportunity of expressing my appreciation for advice and suggestions throughout the progress of the work to Miss Charles and Miss Greenfield.)

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[1] Submitted to the Department of Botany and to the Faculty of the Graduate School of the University of Kansas in partial fulfillment of the requirements for the degree of Master of Arts.

HISTORICAL.

The study of the microörganisms in water has gone hand in hand with the development of the compound microscope, dating back to the seventeenth century. In 1850, Doctor Hassall of London first called attention to the fact that these organisms have a sanitary significance in drinking water. In 1887, the first systematic examination of the water supplies in this country was made by the Massachusetts State Board of Health. This work has been continued up to the present time. During this period surveys of the algæ of the water supplies have been made in several states preliminary to the practical work of the sanitary engineers.

The first data upon the algæ found in Kansas was published in September, 1884, in a bulletin of the Washburn Laboratory of Natural History. This list of twelve species was identified by the Rev. Francis Wolle of Bethlehem, Pa., and was incorporated in the Biological Survey which Francis W. Cragin, professor of natural history, was conducting at Washburn college. In January, 1885, a second list was published containing thirteen new species and additional localities for species reported in the first list. In July, 1886, a third list was published containing five new species and a paragraph on the methods of collecting algæ to be sent in to the laboratory for identification. The final list in January, 1889, was on the Diatomaceæ of the sand from a brook near Arlington, Reno county. Twenty-three species of eleven different genera were listed. In 1911, Prof. B. B. Smyth, curator of the Kansas Museum of Natural History, announced the preparation of a catalogue of the algæ to complete his list of the plants of the state. This plan was left unrealized by his death in 1913. At the University several lists have been prepared which I am compiling for publication as a preliminary survey of the algæ of Kansas. At present the four papers by Wolle, containing the names and localities of fifty-three species of algæ, include all of the work on this subject that has been published for the state of Kansas.

In our neighboring states considerable work on the listing of the local algæ has been published. Nebraska, through its Botanical Survey, has issued several bulletins with lists of algæ prepared by Professors Bessey (1-2-3-25), Pound (1-2-3), Clements (1-2-3) and Webber (24-25). In Iowa, R. E. Buchanan published in 1908, "Notes on the Algæ of Iowa." Colorado has two lists, one on the "Desmida from Alpine Stations," by G. H. Wailes (23), and a "Preliminary List of the Algæ of Colorado," by W. W. Robbins (15). Missouri has a survey bulletin prepared by Miss Ada Hayden (11) on the "Algæ Flora of the Missouri Botanical Garden of St. Louis," containing about one hundred and twenty-five species. The Englemann Botanical Club (9) has prepared a "Preliminary Check List of the Cryptogams and Phanerogams in the Vicinity of St. Louis, Mo.," containing a list of about 135 species of algæ. Oklahoma has published no lists of their algal flora.

RELATION OF ALGÆ TO WATER SUPPLIES.

In Massachusetts the work, including the surveys, carried on for the State Board of Health by Calkins (5), Whipple (26) and others, has shown the marked effect that heavy growths of certain genera of algæ have upon the usability of drinking water. In the first place, the water is often given a very disagreeable odor. For a time this was thought to be due only to the disintegration of the algæ, but was later shown to be caused also by the aromatic oils which are natural to certain species. Some organisms may grow in great abundance without imparting any odor whatsoever to the water, while others, though present in comparatively small quantities, render the water unfit for drinking purposes. Whipple (26) has prepared a table, parts of which are copied below, giving the natural odors of the three large classes of algæ:

TABLE I.

Group.	*Organisms.*	*Natural odors.*
Aromatic odor	Diatomaceæ	Aromatic, geranium, fishy.
Grassy odor	Myxophyceæ	Grassy, moldy, green-corn, nasturtium, sweet.
Fishy odor	Chlorophyceæ	Fishy.

The odors of decomposition are usually more offensive than the natural odors. The Myxophyceæ when decaying give a "pig-pen" odor, Beggiotoa gives the odor of hydrogen sulphide or "rotten eggs," while to some of the other genera the odor of garlic, onions, etc., is ascribed. Water having these strong odors also has a very disagreeable taste. The decaying vegetation often gives the water in addition a yellowish brown color, making it unattractive and in some cases unfit for use even for washing purposes.

Besides this trouble with odors, tastes and color, the algal forms do much damage in clogging the filters and decreasing the length of run quite materially. The diatoms and other unicellular algæ cause the most trouble because of the dense mat which they are able to form over the top of the sand. The filamentous algæ, which grow erect upon the sand, do not thus clog the filter, but on the contrary, they prevent clogging to some extent by their waving threads. However, when these forms decay they, too, settle to the bottom and block the filter. Another danger to the filter is due to the release of gas by these plant forms which at times is sufficient to cause great masses of the mat to rise, thus exposing the sand so that the water filters through it much more rapidly than it should to give efficient results in the tap water.

The elimination of the algæ from the filters can be accomplished by covering them, since these plants can live only in the light. The eradication of the algæ from the reservoirs was a problem, until Moore and Kellerman (14) in 1905 issued a report stating their successful experiments in the removal of algæ by the use of copper sulphate. This treatment has been in practice ever since and has proven to be entirely satisfactory. The method of application as given in the above mentioned paper is as follows: "Place the required number of pounds of copper sulphate in a coarse bag—gunny sack, or some equally loose mesh—and

attaching this to the stern of a rowboat near the surface of the water, row slowly back and forth over the reservoir, on each trip keeping the boat within ten to twenty feet of the previous path. In this manner about one hundred pounds of copper sulphate can be distributed in one hour.———"

It is of great importance to determine the exact proportion of copper sulphate to the volume of water to be dosed, since too small a proportion will not affect the algæ, and too great involves unnecessary expense, and may kill off the fish. The quantity of water to be treated in a large impounding reservoir may be estimated by multiplying the number of acres of water surface by the average depth (taken as about one-third of the maximum depth), and dividing this product by three. This gives approximately the number of million gallons of water in the reservoir. (Whipple 26, page 256.)

Since some genera of algæ require more copper sulphate than others (Moore and Kellerman), it is quite essential that the genus of the algæ causing the trouble be determined by microscopical examination. The algæ which appeared in the reservoirs in the two years' survey, and which, therefore, are the most common in Kansas, may be identified by the descriptions in the key and drawings included in this report.

After the quantity of water to be treated and the causitive organisms have been determined, the dosage of copper sulphate may be found by referring to Table II adapted from Whipple (26) and Kellerman (12), page 9.

Immediately following the killing off of the algæ by copper sulphate, the odor often increases for a few days because of disintegration, but this soon passes away. Another effect of the disintegration of the algæ is the perceptible increase in the bacterial count. This can be kept down by the proper use of hypochlorite, which has been used to some extent as an algacide, but has been found to be not as satisfactory as copper sulphate.

When the use of copper sulphate as an eradicator for algæ was first advocated, the question arose as to its effect upon the human system. Ample data is presented in the Moore and Kellerman paper to show that copper salts are used medicinally, and that copper is widely distributed in nature, so that we take it into our bodies in vegetables and other food to such an extent that the amount which we would get in copper treated waters would not be at all toxic.

Aeration also has a marked effect in the decrease of the algæ by liberating the carbon dioxide gas, which is essential to these plants for the manufacture of their food.

TABLE II.

Quantity of copper sulphate required for different organisms.

Organisms.	Parts per million.	Pounds per million gallons of water.
Bacillarieæ.		
Asterionella	0.10	0.8
Fragilaria	0.25	2.1
Melosira	0.30	2.5
Synedra	1.00	8.3
Navicula	0.07	0.6
Flagellata.		
Euglena	1.00	8.3
Dinobryon	0.30	2.5
Myxophyceæ.		
Anabæna	0.09	0.75
Aphanizomenon	0.15	1.2
Clathrocystis	0.10	0.8
Oscillatoria	0.10 to .4	0.8 to 3.3
Chlorophyceæ.		
Cladophora	1.00	8.3
Conferva	0.40 to 2	3.3 to 16
Chlamydomonas	0.50	4.2
Draparnaldia	0.30	2.5
Microspora	0.40	3.3
Scenedesmus	0.30	2.5
Spirogyra	0.05 to .3	0.4 to 2.5
Raphidium	0.30	2.5
Ulothrix	0.20	1.7
Zygnema	0.70	5.8

Then, too, the odors of the algæ are liberated by this treatment. Many of the superintendents of water works of the southern part of Kansas use the aerating system to free the water from the sulphur odor.

S. T. Powell (17) in 1914 reports a ready removal of certain kinds of algæ from drinking water by direct oxidation with ozone, but from a practical point of view this method has never been developed.

Throughout the country much work is being done upon the algæ with special attention to the control of growths in water supplies. With the increasing population will come a larger number of surface water supplies, necessitating more attention on the part of the sanitary engineers to the pollution of the water by algæ.

METHODS.

The cities of Kansas that furnish surface water to the public are compelled by the rules and regulations of the State Board of Health, 1915 (16), to send samples of water collected weekly to be analyzed in the water and sewage laboratory at Lawrence. There are now forty-three such water supplies in the state distributed as appears on the map, plate I. From the reservoirs and basins of the water supplies of these cities the material for this report was obtained. Collections were made in the summer and winter of 1915 and the spring, summer and winter of 1916. This checking of each reservoir five times should bring out any changes due to differences in the seasons and gives us a more complete record on the flora of each reservoir.

The bottles used in collecting the algæ were large-mouthed, glass-stoppered, 100 cubic centimeter bottles, usually filled about one-half full of a two per cent solution of formalin, and bearing the following inscription: "Collect green moss or slime from settling basin. Look carefully near the walls. Do not pour out the liquid in this bottle, but collect slime with a dipper or hand and pour into the bottle." The bottles were

placed in the containers with those for the water samples, and were back for analysis within a week after shipment. Most of the analyses were made from preserved material; however, one complete analysis was made from each town on the living material, which was shipped into the laboratory on ice, and allowed to grow in aquaria.

In most cases the algæ were present in sufficient quantities to examine direct from the samples. In those cases in which small masses of the algæ, "moss," could not be found in the basin or reservoir, a liter of water from the basin was taken and the microörganisms present concentrated by the Sedgwick-Rafter filter method (Whipple, 26, page 28). This method of determining the actual number of microörganisms per cubic centimeter of water is especially valuable in recording the reduction of organisms per cubic centimeter during the copper sulphate treatment. By this method it was often difficult to identify accurately the organism under the 16 mm. objective. In order to overcome this difficulty a few drops of the water containing the concentration of organisms was mounted in the usual method under the 4 mm. or higher power. Most of the species found by this method were diatoms and other unicellular algæ.

At times samples of living algæ came into the laboratory in a vegetative condition and the species could not be accurately determined without the fruiting state. This was especially true of the Conjugatæ. For such algæ Kelbs' method was used to induce the fruiting stage (Chamberlain, page 163). According to this method such forms as Spirogyra in a vegetative state were placed in an aquarium of about .2 per cent Knop's solution and left to grow for a few days. When a vigorous growth was shown the algæ were transplanted to a jar of distilled water in the sunlight. In most cases these conditions caused conjugation necessary for classification to species.

In dosing the reservoirs with copper sulphate I have in most cases used the Moore and Kellerman (14) method.

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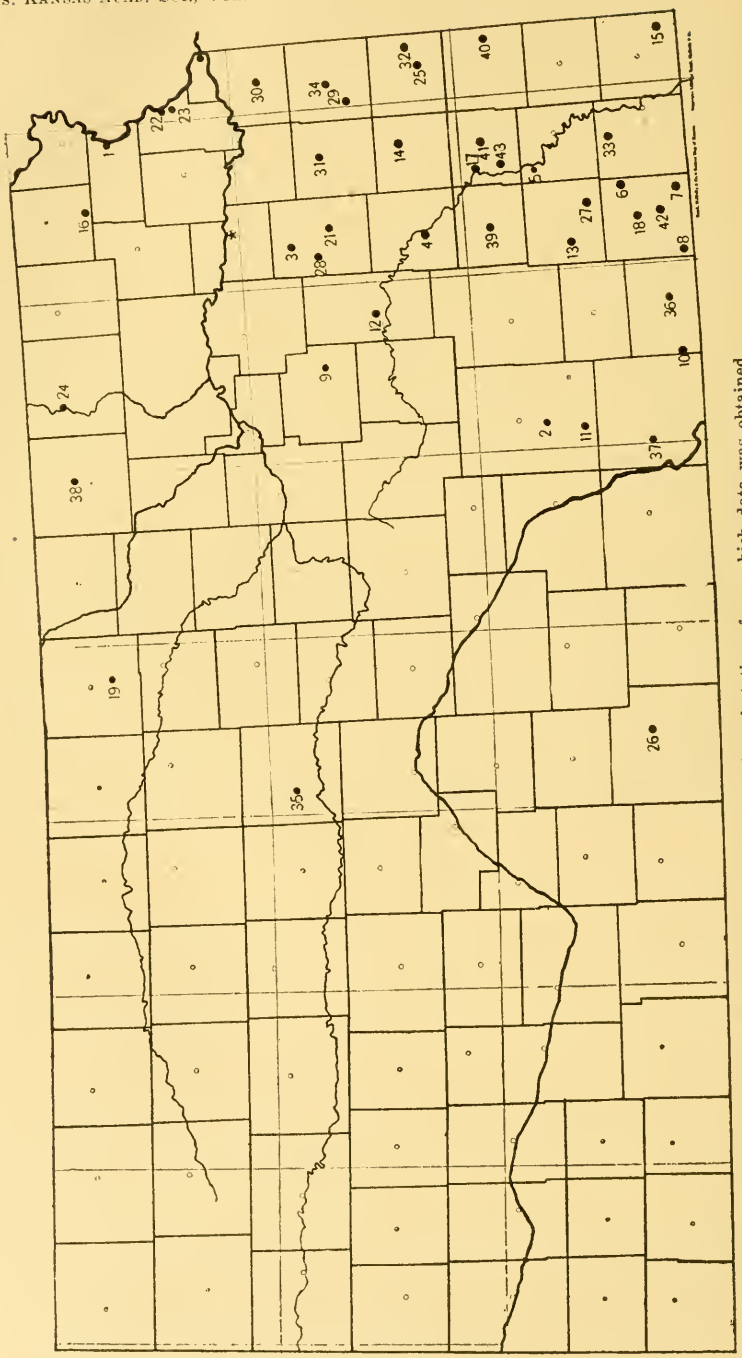

Map of Kansas showing location of stations from which data was obtained.

CITIES HAVING SURFACE WATER SUPPLIES.

1. Atchison.
2. Augusta.
3. Burlingame.
4. Burlington.
5. Chanute.
6. Cherryvale.
7. Coffeyville.
8. Caney.
9. Council Grove.
10. Cedarvale.
11. Douglass.
12. Emporia.
13. Fredonia.
14. Garnett.
15. Galena.
16. Horton.
17. Iola.
18. Independence.
19. Jewell City.
20. Kansas City.
21. Lyndon.
22. Leavenworth.
23. Lansing.
24. Marysville.
25. Mound City.
26. Medicine Lodge.
27. Neodesha.
28. Osage City.
29. Osawatomie.
30. Olathe.
31. Ottawa.
32. Pleasanton.
33. Parsons.
34. Paola.
35. Russell.
36. Sedan.
37. Winfield.
38. Washington.
39. Yates Center.
40. Fort Scott.
41. La Harpe.
42. Dearing.
43. Humboldt.

OBSERVATIONS.

The following key contains the species of algæ which I have found during the period of two years devoted to the collection of data for this report. The list has been prepared in a key form so as to be an aid to those who do not have access to the literature on algæ.

MYXOPHYCEÆ, sometimes called *Cyanophyceæ*, or *Schizophyceæ*, are commonly called the Blue-Green Algæ because of their typically blue-green color. Plants one or many celled, often associated together into families in the form of filaments, spherical or regular gelatinous masses. Some forms endowed with a peculiar motion. Plants found in aerial situations, as endophytes, on rocks, trees, and tanks, especially in fresh, brackish, or salt water, in hot springs and mineral springs.

Key to the Orders of Myxophyceæ.

I. Plants unicellular, single or associated in families or colonies, commonly surrounded by copious gelatinous integument, rarely forming filaments ..... *Coccogoneæ.*

II. Plants multicellular, filamentous, filaments simple or branched, generally consisting of one or more cells within a sheath, attached to a substratum or free-floating..... *Hormogoneæ.*

ORDER I. COCCOGONEÆ.

Key to the Families of Coccogoneæ.

I. Plants epiphytic, often differentiated into basal and apical regions; reproduction by means of nonmotile gonidia..... *Chamæsiphonaceæ.*

II. Plants very rarely epiphytic, not differentiated into basal and apical regions; reproduction by vegetative division of cells in 1, 2, or 3 directions ..... *Chroococcaceæ.*

Family I. CHAMÆSIPHONACEÆ.

None of the species belonging to this family have been found in the city water reservoirs.

Family II. CHROOCOCCACEÆ.

Key to the Genera of Chroococcaceæ.

Plants solitary or associated in families or colonies, surrounded by a common gelatinous tegument.

A. Colonies without definite shape, individual sheaths thick, remaining through many divisions, sheath of original mother cell surrounding entire colony; cells spherical enclosed in sheath single or in colonies; cell contents blue-green.....1. *Gleocapsa.*

B. Colonies having a definite characteristic shape, free-floating.

* Cells spherical, having an indefinite arrangement, forming several layers; colonies of variable shape, at first solid, becoming saccate and clathrate.....2. *Clathrocystis.*

** Cells spherical having a definite rectangular arrangement, forming a single layer.....3. *Merismopedium.*

1. *Gleocapsa.*

1. G. arenaria (Hassall) Rabenhorst. Plate II, fig. 1.
Kansas: Paola, July, 1916.
Iowa (4).

2. *Clathrocystis.*

2. C. æruginosa (Kuetzing) Henfrey.
Kansas: Emporia, found in large amounts in August and November, 1915; March and August, 1916; Osawatomie, November, 1915; April, 1916; Burlington, April, 1916; Coffeyville, July, 1916.
Iowa (4); Missouri (11).

3. *Merismopedium.*

Key to Species.

Diameter of cells, 3-6 mic., colonies, 45-150 mic. in diameter .....*M. glaucum.*
Diameter of cells, 1-3.2 mic.....*M. tenuissimum.*

3. M. glaucum (Ehrenberg) *Nägeli.* Plate II, fig. 2.
Kansas: Garnett, August, 1916; Lyndon, March, 1916; Osawatomie, August and November, 1916; Coffeyville, October, 1916.
Iowa (4); Nebraska (24); Colorado (15).

4. M. tenuissimum Lemmermann.
Kansas: Burlingame, October, 1916.
Colorado (15); Missouri (11).

ORDER II. HORMOGONEÆ.

Key to Families of Hormogoneæ.

I. Filaments frequently branched, containing one or more trichomes; sheaths variable, more or less gelatinous; trichomes consisting of a simple row of cells uniform along their entire length, except for the apical cells which are sometimes attenuated; heterocysts absent; reproduction by vegetative division.....*Oscillatoriaceæ.*

II. Sheaths very delicate, often invisible; trichomes usually tortuous and entangled, consisting of a single row of uniform cells, with heterocysts; reproduction by means of vegetative division, hormogones and gonidia .....*Nostocaceæ.*

Family I. Oscillatoriaceæ.

Key to Genera.

A. Sheaths not present.

* Trichomes cylindrical, straight or nearly so, never forming a regular spiral, free, apex of trichome straight or curved. 1. *Oscillatoria.*

** Trichomes unicellular, forming a regular, more or less lax spiral ..... 2. *Spirulina.*

B. Sheaths present.

* Filaments simple; sheaths cylindrical, firm; trichomes single within the sheath; apex of trichome straight.

a. Filaments simple, more or less agglutinated by their mucus sheaths ..... 3. *Phormidium.*

b. Filaments simple, free, free-floating or forming a matted mass ..... 4. *Lyngbya.*

** Filaments frequently branched; sheaths firm, lamellose, transparent or colored; trichomes several with the sheath.

a. Sheaths solid, colorless, filaments prostrate, woven into more or less compact membranaceous mass. 5. *Hypheothrix.*

b. Sheaths mucous, not lamellose, always transparent; trichomes many within the sheath..... 6. *Microcoleus.*

1. *Oscillatoria.*

Key to Species.

I. Apex of trichome constantly straight, finally capitate.

A. Trichomes tapering, 4-6 mic. in diam.; cells quadrate or shorter, but never very short; plant mass light blue-green... *O. agardhii.*

B. Trichomes not at all or briefly tapering, 6-8 mic.; often interrupted by inflated refringment cells..... *O. anguina.*

II. Apex straight or curved, not tapering.

A. Trichomes, 4-10 mic. in diam., slightly constricted at the joints; cells, 2.6-5 mic. in length; transverse walls usually furnished with two rows of granules..... *O. tenuis.*

B. Trichomes, 2-3 mic. in diam., not constricted at the joints; cells, 4-8.5 mic. in length, commonly marked with two protoplasmic granules ..... *O. amphibia.*

C. Trichomes, 1-1.5 mic. in diam., often rolled in circinate manner. *O. subtilissima.*

D. Trichomes, 3.5-4 mic. in diam., not constricted at joints; transverse walls not granulated..... *O. chlorina.*

E. Trichomes, .6 mic. in diam., flexible, tangled, not constricted at joints ..... *O. angustissima.*

III. Apex of trichome tapering, more or less jointed, hooked or flexuous, not entirely spiraled.

A. Apical cell capitate.

1. Trichomes, 2-3 mic. in diam., cells longer than their diameter ..... *O. splendida.*

2. Trichomes, 2.5-5 mic. in diam., cells somewhat quadrate. *O. amoena.*

B. Apical cell not capitate.

1. Trichomes, 4-6.5 mic. in diam., here and there interrupted by inflated refringent cells; apex of trichome briefly tapering, hooked or flexuous; cells three times shorter than their diameter. ..... *O. brevis.*

2. Trichomes, 4-7 mic. in diam.; apex of trichome obtuse, straight, rarely curved.....*O. cruenta.*
3. Trichomes, 5.5-8 mic. in diam.; slightly constricted at joints; apex of trichomes very gradually tapering, hooked or undulating; cells very long near the apex....*O. cortiana.*

IV. Apex of trichome tapering, not capitate, trichome regularly terebriform, forming a spiral throughout the entire length.

A. Trichomes, 6-8 mic. in diam. .....*O. boryana.*

B. Trichomes, 4-6.5 mic. in diam.....*O. terebriformis.*

5. O agardhii Gomont.
Kansas: Masses at Augusta, August, 1915; Fredonia, August, 1915; Winfield, August, 1915; Cherryvale, November, 1915; Masses at Council Grove, April, 1916.
Missouri (11).

6. O. anguina Bory.
Kansas: Marysville, October, 1916, mixed with *O. splendida* in mats.

7. O tenuis Agardh. Plate II, fig. 3.
Kansas: Burlingame, August, 1915; Ottawa, April, 1916; Pleasanton, August, 1915; Yates Center, August, 1915; Horton, June, 1916.
Nebraska (24); Colorado (15); Missouri (11).

8. O. amphibia Agardh.
Kansas: Most common species found. Identified over forty times.
Iowa (4); Nebraska (3); Missouri (11).

9. O. subtilissima. Kuetzing.
Kansas: Iola, August, 1915; Parsons, August, 1915, March, 1916; Yates Center, August, 1915.

10. O. chlorina Kuetzing.
Kansas: Lyndon, August, 1915, March, 1916.
Nebraska (3).

11. O. angustissima W. & G. S. West.
Kansas: Paola, August, 1915.
Iowa (4).

12. O. splendida Greville. Plate II, fig. 4.
Kansas: Chanute, August, 1916; Coffeyville, August, 1915, March, October, 1916; Cherryvale, November, 1915, October, 1916, along with *O. tevebriformis* forming a mat of deep blue-green on edge of reservoir. Horton, June, October, 1916; Marysville, October, 1916; Osawatomie, October, 1916; Pleasanton, August, 1915; Winfield, August, 1916.
Missouri (11).

13. O. amœna Kuetzing.
Kansas: Mound City, March, 1916; Leavenworth, August, 1916; lining reservoir with deep blue-green carpet.

14. O brevis Kuetzing. Plate II, fig. 5.
Kansas: Burlingame, March, August and November, 1915; April, 1916; Coffeyville, July, 1916; Fort Scott, April, 1916; Horton, June, 1916; Independence, August, 1915; March, 1916.

15. O. cruenta Grunow.
Kansas: Masses, Leavenworth, August, 1915, November, 1915, August, 1916.

16. O cortiana Meneghini.
Kansas: Chanute, August and November, 1915, April, 1916.

17. O. boryana Bory.
Kansas: Much, Emporia, November, 1915.

18. O. terebriformis Agardh.
Kansas: Kansas City, August, 1915; Cherryvale, October, 1916; Paola, August and November, 1915; Washington, August, 1915.

2. *Spirulina.*

Key to Species.

I. Trichomes, 1.2-1.7 mic. in diam., forming a loose irregular spiral. *S. major.*

II. Trichomes, 2 mic. in diam., flat, forming continuous band (untwisted, forming a complete ring) with one to four turns.....*S. duplex.*

19. S. major Kuetzing. Plate II, fig. 6.
Kansas: Atchison, August and November, 1915; Douglass, August, 1915; Coffeyville, October, 1916; Osawatomie, July, 1916, velvety, dark blue-green masses, slimy, mixed with *O. amphibia,* October, 1916; Winfield, August, 1915.
Iowa (4); Nebraska (3); Colorado (15); Missouri (11).

20. S. duplex Wolle.
Kansas: Coffeyville, October, 1916.

3. *Phormidium.*

Key to Species.

I. Apex of trichome straight, not capitate, trichomes 3-5 mic. in diam., not constricted at joints, cells 2-4 mic. in length; transverse walls conspicuous.....*P. papyraceum.*

II. Apex of trichome straight, briefly tapering, capitate trichomes 5.5-11 mic. in diam., not constricted at joints, cells 2-4 mic. in length. *P. subfuscum.*

21. P. papyraceum Agardh.
Kansas: Horton, June, 1916.

22. P. subfuscum Kuetzing.
Kansas: Iola, December, 1915.

4. *Lyngbya.*

Key to Species.

I. Trichomes not more than 2 mic. in diam.; sheaths thin, colorless, filaments straight or curved.

A. Filaments 1.9 mic. in diam.; cells 1-1.5 mic. long, contents pale steel color.....*L. nana.*

B. Filaments 1.5-1.8 mic. in diam., cells up to 3.6 mic. long, contents pale blue-green.....*L. subtilis.*

II. Trichomes 2-6 mic. in diam.; sheaths usually thin, and colorless, but sometimes thick and yellowish.

A. Sheaths often becoming thick and lamellose; trichomes 2.5-6 mic. in length; filaments coiled.....*L. lutea*

B. Sheaths thin and colorless; plant mass light green; trichomes 2-3 mic. in diam., not constricted at joints; cells 1-3.7 mic. in length .....*L. digueti.*

C. Sheaths colorless and firm; plant mass dull blue-green; trichomes 4-6 mic. in diam., not constricted at joints; cells 2.3-3 mic. in length .....*L. ærugineo-cærulea*

III. Trichomes 5-25 mic. in diam.

A. Trichomes 8-24 mic. in diam.; apex of trichome slightly tapering, capitate; cells 2.7-5.6 mic. in length; sheaths thickened and yellow with age.....*L. æstuarii.*

B. Trichomes 6-10 mic. in diam.; apex of trichomes not tapering, not capitate; cells 1.7-3.3 mic. in length; sheaths thickened and roughened with age.....*L. martensiana*

C. Trichomes 11-16 mic. in diam.; apex of trichomes slightly tapering, somewhat capitate; cells 2-3.4 mic. in length, transverse walls granular; dark blue-green cell contents, sheaths colorless, thick and roughened.....*L. major.*

D. Trichomes 7.5-13 mic. in diam., constricted at the joints; apex of trichomes not tapering, not capitate; cells 3-10 mic. in length; sheaths colorless, thin, papery.....*L putealis.*

23. *L. nana* Tilden
Kansas: Masses, Burlington, August, 1915, April, 1916; Council Grove, October, 1916.

24. *L. subtilis* W. West.
Kansas: Ottawa, November, 1915.

25. *L. lutea* Agardh.
Kansas: Iola, August, 1915, December, 1915, March, 1916; masses, Ottawa, November, 1915, October, 1916, dense masses of yellow color; much, Osawatomie, April, 1916, October, 1916; Washington, August, 1916.

26. *L. digueti* Gomont.
Kansas: Coffeyville, November, 1915, July, 1916, masses; Washington, August, 1916.
Missouri (11).

27. L. *ærugineo-cærulea* Kuetzing, Gomont.
Kansas: Council Grove, November, 1915, July, 1916, October, 1916, calcarious deposite; Atchison, October, 1916, slimy velvety growth, carpet; Emporia, March, 1916, August, 1916; Lansing, November, 1915, March, 1916, August, 1916; Paola, March, 1916.
Colorado (15).

28. *L. æstuarii* Mertins Liebman.
Kansas: Coffeyville, August, 1915, November, 1915.
Iowa (4); Nebraska (25).

29. *L. martensiana* Meneghini.
Kansas: Atchison, August, 1915, March, 1916; much, Emporia, November, 1916, August, 1916; Burlington, April, 1916; Coffeyville, July, 1916.
Variety: *Calcarea* Tilden.
Kansas: Lyndon, October, 1916, about edge in calcareous material.

30. *L. major* Meneghini.
Kansas: Neodesha, October, 1916, masses.
Nebraska (3).

31. *L. putealis* Montagne. Plate II, fig. 7.
Kansas: Chanute, August, 1916; Cherryvale, October, 1916, mat about edge of reservoir along with *O. splendida* and *O. terebriformis;* Kansas City, March, 1916; Winfield, August, 1916, March, 1916.

5. *Hypheothrix.*

32. *H. coriacea* Kuetzing.
Filaments long and flexible; plant mass encrusted with calcium carbonate; trichomes 1-1.7 mic. in diam.
Kansas: Leavenworth, April, 1916.

6. Microcoleus.

33. M. Paludosus Kuetzing Gomont.
Apical cell not capitate; sheaths somewhat mucous; trichomes 5-7 mic. in diam., not constricted at the joints.
Kansas: Paola, November, 1915, August, 1915.

Family II. NOSTOCACEÆ.

Key to Genera.

A. Trichomes flexuous and contorted; within a definite gelatinous investment .....1. *Nostoc.*

B. Trichomes more or less straight, free or forming a thin mucous stratum; heterocysts and spores intercalary.....2. *Anabæna.*

1. *Nostoc.*

34. N. punctiforme Kuetzing Hariot.
Plants microscopic, granular, aggregated; filaments closely entangled; trichomes scarcely distinct.
Kansas: Lyndon, November, 1915; Horton, June, 1916.

2. *Anabæna.*

Key to Species.

I. Gonidia oval or spherical, removed from heterocysts in catenate series; trichomes 4-6 mic. in diam.; heterocysts 6 mic. in diam.; 8 mic. in length; gonidia 7-9 by 8-14 mic.....*A. variabilis.*

II. Gonidia cylindrical, curved, variously disposed, trichomes 4-8 mic. in diam.; gonidia 7-13 mic. in diam. and 20-50 mic. in length. *A. flos-aquæ.*

35. A. variabilis Kuetzing. Plate II. fig. 9.
Kansas: Horton, August, 1916, great masses along with *A. flos-aquæ,* causing serious trouble by discolorations, bad taste and odor of water.

36. A flos-aquæ. Breb. Plate II. fig. 10.
Most common form.
Kansas: Horton, August, 1916; Paola, July, 1916; Coffeyville, March, 1916.
Colorado (15); Iowa (4); Neb. (24); Mo. (11).

CLASS II.

FLAGELLATA is an order of the class Mastigophora of the Protozoa. Cells nucleated with definite external layer of protoplasm provided with one or more vibratile long whip-like flagella; food commonly ingested through the oral aperture; some genera contain chlorophyll and are sustained by nutritional processes resembling those of plants; protoplasm of the cell contains chromatophores, pigment spots, oil globules, etc.

Key to the Sub-Orders of Flagellata.

I. Mostly small animals with one large flagellum and frequently one or more smaller secondary flagella.....*Monadina.*

II. Larger animals, commonly with one large flagellum, mouth and commonly pharynx at the base of the flagellum.....*Euglenoidina.*

Sub-Order I. MONADINA.

Colonies, free swimming, yellow to brown; an urn-shaped lorica with an acute posterior end set inside the mouth opening of another individual; 2 chromatophores and an eye-spot and 2 unequal flagella....*Dinobryon.*

Dinobryon

37. D. setularia Ehrbg. Plate II, fig. 11.
Kansas: Parsons, August, 1915.

Sub-Order II. Euglenoidina.

Free swimming animalcules, exceedingly flexible in form; spirally marked resistent cuticle; chromatophores green; mouth and pharynx evident, with long flagellum arising from mouth; vacuole at lower end of pharynx with eye-spot close by.....*Euglena.*

38. E. viridis Ehrbg. Plate II, fig. 12.
Kansas: Douglas, August, 1915; Horton, August, 1916, June, 1916; Lyndon, November, 1915; Osawatomie, February, 1917; Council Grove, October, 1916.
Neb. (24); Mo. (11).

CLASS III.

HETEROKONTÆ are characterized by yellow-green chromatophores which are disc shaped, parietal, and lack pyrenoids; motile cells are biciliate with cilia of unequal length; reserve material is oil, not starch.

Order I. CONFERVALES.

The only family of this order found in our city water reservoirs is the Confervaceæ, which are unicellular or filamentous. There are usually many disk-shaped chromatophores, and the cells contain one or more nuclei.

Key to the Genera of Confervaceæ.

A. Cells elongate, united into filaments, cell wall thin, breaking up into H sections; asexual reproduction by biciliate zoospores, 1-4 in a cell .....1. *Conferva.*

B. Cells elongate, solitary, rounded at one end and stipitate at the other; straight, arched, or spiral, often attached to water plants .....2 *Ophiocytium.*

1. *Conferva.*

Key to Species.

I. Chromatophores numerous, filaments 6-11 mic. in diam., 2-4 or 6 diam. long .....*C. Minor.*

II. Chromatophores numerous, filaments 6-11 mic. in diam., 2-4 diam. long .....*C. bombycina.*

III. Chromatophores numerous, filaments 6-16 mic. in diam. 1.5-6 diam. long .....*C. utriculosa.*

39. C. Minor Klebs.
Kansas: Osage City, November, 1915; Masses, Cherryvale, March, 1916; Washington, April, 1916.

40. C. bombycina Agardh.
Kansas: Washington, November, 1915; Burlington, April, 1916; Cherryvale, August, 1915; Chanute, April, 1916; Horton, August, 1915; March, 1916; Neodesha, August, 1915; Mound City, April, 1916.
Colorado (15); Iowa (4).

41. C. utriculosa. Plate II, fig. 13.
Kansas: Marysville, August, 1915, November, 1915, April, 1916, August, 1916.
Iowa (4).

2. *Ophiocytium*

42. O. cochleare Eichwald.
Kansas: Douglas, August, 1915; Medicine Lodge, August, 1915.

CLASS IV.

CHLOROPHYCEÆ are algæ characterized by true grass-green color; single or united into threads, plates or masses; pyrenoids mostly present; reproduction by zoöspores, akinetes and aplanospores.

Key to Orders of Chlorophyceæ.

Frond of one or more cells.

* Vegetative cells ciliate and motile, always or except during resting periods, or easily passing into a motile condition. II. *Volvocales.*

** Vegetative cells motionless; reproductive cells motile or not.

a. Reproduction by zygospores formed by the union of 2 non-ciliated gametes.....I. *Conjugales.*

b. Reproduction by zoospores, not by zygospores.

1. Cells solitary or in a spherical or netlike combination .....III. *Protococcales.*
2. Cells forming simple or branched filaments.

* Cells uninucleate, chromatophore usually single, disk-, net-, or star-shaped.....IV. *Ulotrichales.*

** Cells multinucleate, chromatophore net-shaped, as of numerous small disks in a cell. V. *Siphonocladiales.*

ORDER I. CONJUGALES.

Key to Families of Conjugales.

I. Cell wall mostly constricted into symmetrical halves with a differentiated outer layer; solitary or in filaments; cell division follows a fixed type, with interpolation of the younger halves between the old ones .....1. *Desmidiaceæ.*

II. Cells cylindrical, without constrictions, always united in filaments; the new filament always formed directly from the zygospore.

* The entire protoplasmic contents of the conjugating cells uniting to form the spore.....2. *Zygnemaceæ.*

** Only a part of the contents of the conjugating cells used for the spore .....3. *Mesocarpaceæ.*

Family I. DESMIDIACEÆ.

Key to Genera of Desmidiaceæ.

I. Cells not united into filaments, more or less crescentic. 1. *Closterium.*

II. Cells constricted in middle, dumb-bell shaped; end view not angular, margins smooth, dentate or crenate but no spines....2. *Cosmarium.*

1. *Closterium.*

Key to Species.

I. Cells slightly curved; ends not contracted, but tapering, acute with 40-50 mic. length 5-12 times the width; chlorophyll bands, several granules in one row.....*C. lanceolatum.*

II. Cells conspicuously curved, often subsemicircular; width 16-25 mic., cytioderm smooth .....*C. Dianæ.*

43. C. lanceolatum Kuetzing.
Kansas: Burlingame, August, 1915; Horton, October, 1916.
Colorado (15); Iowa (4); Nebraska (25).

44. C. Dianæ Ehrbg. Plate III, fig. 14.
Kansas: Neodesha, November, 1915; Horton, June, 1916.
Iowa (4); Nebraska (25).

2. *Cosmarium.*

Key to Species.

I. Single chloroplast (with one pyrenoid) in semi-cell.
  A. End view without central inflations, cytioderm punctate, margins granulate, semi-cell semi-obicular, diam. 12-16 mic., *C. leve.*

II. Two chloroplasts (with two pyrenoids) in each semi-cell.
  A. Membrane smooth or lightly punctate. End view with central inflations, margins smooth, sinus acute inwardly, diameter 12-30 mic. .....*C. tithophorum.*
  B. Membrane verrucose, rarely heavy punctate.
    1. End of semi-cells broadly rounded, diam. 60-68 mic. *C. perforatum.*
    2. End of semi-cells truncate, diam. 35-62 mic....*C. Botrytis.*

45. *C. leve* Rabenh.
Kansas: Douglass, 1916.
Iowa (4).

46. *C. tithophorum* Nordst.
Kansas: Douglass, August, 1915.

47. *C. perforatum* Lund.
Kansas: Douglass, August, 1915.

48. *C. Botrytis* (Bory) Menegh. Plate III, fig. 15.
Kansas: Horton, June, 1916, October, 1916; Parsons, August, 1915; Jewell City, 1915; Lyndon, November, 1915; Coffeyville, July, 1916; Burlingame, October, 1916.
Colorado (15); Iowa (4); Nebraska (25); Missouri (11).

Family II. Zygnemaceæ.

Key to the genera of Zygnemaceæ.

I. Chromatophores one or two, star-shaped.....1. *Zygnema.*
II. Chromatophores one or more, parietal, more or less spiral. 2. *Spirogyra.*

1. *Zygnema.*

49. *Z.* ——— *sp.?*
Kansas: Horton, June, 1916.

2. *Spirogyra.*

Key to Species.

I. Septa between cells smooth, not folded back or replicate.
  A. Fruiting cells little or not at all swollen.
    1. One chromatophore in each cell.
      a. Zygospore broad ovoid, 1.5-2.5 times as long as wide, diam. 18-20 mic.....*S longata.*
      b. Zygospore ellipsoid, 2-3 times as long as wide, diam. 19-23 mic. .....*S. communis.*
    2. Two or more chromatophores in each cell.
      a. Zygospore ovoid or globose, vegetative filaments 33-40 mic. in diam., cells 2-4 times as long as wide. *S. decimina.*
      b. Zygospore compressed ovoid, 140-160 mic. in diam., vegetative filaments, 150-160 mic. in diam.....*S. crassa.*
  B. Fruiting cells distinctly swollen, one chromatophore in each cell, end walls replicate, filaments 24-33 mic. in diam., zygospore ellipsoid, 40-48 mic. in diam.....*S. quadrata.*

50. *S. longata* Kuetz. Plate III, fig. 16.
Kansas: Coffeyville, October, 1916.
Iowa (4); Colorado (15); Mo. (11).

51. *S communis* Kuetz.
Kansas: Horton, June, 1916.
Iowa (4).

52. *S. decimina* Kuetz.
Kansas: Horton, June, 1916, masses.
Iowa (4); Nebraska (24).

53. *S. crassa* Kuetz.
Kansas: Gardner, June, 1916, great masses.
Iowa (4); Colorado (15); Nebraska (25).

54. *S. fluviatilis* Hilse.
Kansas: Paola, November, 1915; July, 1916; masses.
Iowa (4); Nebraska (24).

55. *S. quadrata* (Hass) Petit.
Kansas: Burlingame, October, 1916.
Iowa (4); Nebraska (24).

Family III. Mesocarpaceæ.

Chromatophore an axillary plate with two or more pyrenoids. *Mougeotia.*

56. *M. elegantula* Whittrock.
Kansas: Pittsburg, September, 1915.

57. *M. delicatula* Wolle.
Kansas: Douglass; November, 1915; April, 1916; June, 1916.

58. *M.* ——— *sp.*?
Kansas: Horton, June, 1916, mixed with Spirogyra and Zygnema.

59. *M.* ——— *sp.?*
Kansas: Chanute, August, 1916, only a few strands.

Order II. VOLVOCALES.

Key to Families of Volvocales.

1. Cells free, never forming colonies.....1. *Chlamydomonadaceæ.*
II. Cells united in colonies.
  * Colonies of various form, cells motile when free, sometimes when in colonies.....3. *Tetrasporaceæ.*
  * * Colonies spherical, ovoid, or disk-shaped; vegetative cells normally always motile.....2. *Volvocaceæ.*

Family I. Chlamydomonadaceæ.

Key to genera of Chlamydomonadaceæ.

I. Cells spherical or ovoid.
  * Protoplasmic threads passing through the cell wall. 1. *Hæmatococcus.*
  * * No protoplasmic threads in cell wall.....2. *Chlamydomonas.*

1. *Hæmatococcus*

60. *H. pluvialis* Flotow. (*H. lacustric* Girod).
Kansas: Osawatomie, August, 1915.
Nebraska (2); Colo. (15).

2. *Chlamydomonas.*

61. *C. communis* Snow. Plate III, fig. 17.
Kansas: Augusta, August, 1915; Fredonia, August, 1915.
Kansas: Jewell City, August, 1915; Chanute, November, 1915; Osawatomie, November, 1915; Cherryvale, October, 1916; Burlington, April, 1916; Lyndon, March, 1916.

Family II. VOLVOCACEÆ.

1. *Pandorina.*
Colony globose, of 16-32-64 rotund cells; cells surrounded by a firm membrane.

62. *P. Morum* (Müll) Bory. Plate III, fig. 18.
Kansas: Burlington, April, 1916; November, 1915; Lyndon, March, 1916; Emporia, August, 1916; Parsons, October, 1916; Garnett, August, 1916; Paola, November, 1915; Osawatomie, October, 1916.
Iowa (4); Missouri (11).

Family III. TETRASPORACEÆ.

Key to genera of Tetrasporaceæ.

I. Cells and colony with some definite form and arrangement.
* Cells radiately arranged in botryoidal mass. 1. *Botryococcus.*
** Cells not radiately arranged, without stalks, scattered more or less in twos and fours, mature frond an expanded delicate membrane ..... 2. *Tetraspora.*

1. *Botryococcus.*

63. *B. Braunii* Kuetz. Plate III, fig. 19.
Kansas: Gardner, June, 1916.

2. *Tetraspora.*

Key to Species.

I. Frond an irregularly inflated sac.
A. Almost colorless, cells spherical, by twos, variable in size, 3-12 mic. in diam..... *T. gelatinosa.*
B. Green, cells elliptic, angular, unusually small and by twos, 5-7 mic. in diam..... *T. explanata.*
II. Frond at first tubular, but soon splitting into irregular segments, often much perforate, of a yellowish color; cells 7-11 mic. in diam., generally in fours..... *T. lubrica.*

64. *T. gelatinosa* (Vauch) Desv.
Kansas: Council Grove, March, 1916.
Colo. (15); Iowa (4); Mo. (11).

65. *T. explanata* Kuetz.
Kansas: Emporia, March, 1916.

66. *T. lubrica* (Roth).
Kansas: Lansing, October, 1916.
Colorado (15); Iowa (4); Neb. (25).

ORDER III. PROTOCOCCALES.

Key to the Families of Protococcales.

I. Cells united in regular, net- or disk-shaped colonies, not gelatinous III. *Hydrodictyaceæ.*

II. Cells free or united in gelatinous colonies, uninucleate, of definite form, with single chromatophore.
  * Cells dividing vegetatively.....II. *Scendesmaceæ.*
  * * Vegetative cell-division rare and abnormal.
    I. *Protococcaceæ.*

Family I. PROTOCOCCACEÆ.

1. *Characium.*
Cells solitary, often distinctly stipitate.

Key to the Species of Characium.

I. Sessile upon plants, cells 7-9 mic. in diam.....*C. sessile.*
II. Cells erect, at first lanceolate, later ellipsoid, obtuse, 20-42 by 7-18 mic., stipe slender about 4 mic. long.....*C. Nægelii.*

67. *C. sessile* Hermann.
Kansas: Horton, June, 1916.

68. *C. Nægelii* A. Braun. Plate III, fig. 20.
Kansas: Leavenworth, July, 1916.
Iowa (4); Nebraska (24).

Family II. SCENEDESMACEÆ.

Key to genera of Scenedesmaceæ.

A. Plants not living in cell of animals; no external gelatinous thallus.
  * Mature cell solitary, mother cell elongate, acinular or fusiform, dividing by oblique walls into daughter cells.
    1. *Rhaphidium.*
  * * Mature cells united in colonies.
    a. Cells elongate, side by side in a single or double series.
    2. *Scenedesmus.*
    b. Cells without spinous projections, symmetrically arranged about a center, united to the center by gelatinous strands.
      Strands unbranched, short.....3. *Cœlastrum.*
      Strands unbranched, spherical cells at end.
      4. *Dictyosphærium.*

1. *Rhaphidium* (*Ankistrodesmus*).

Key to Species.

I. Cells 12-25 diam. long, ends very acute.....*R. falcatum.*
II. Cells 3-12 diam. long, ends apiculate, cells variously twisted and curved .....*R. convolutum.*

69. *R. falcatum* (Corda) Cooke. (*R. polymorphum* Wolle, *Ankistrodesmus falcatus* (Corda) Ralfs.)
Kansas: Paola, March, 1916; November, 1915; Chanute, November, 1915; Leavenworth, November, 1915; Ottawa, November, 1915.
Iowa (4); Missouri (11); Colorado (15); Nebraska (25).

70. *R. polymorphum* var. *contortum.* (Thur.) Wolle (*A. falcatus* var. *spiralis* (Thur.) West.)
Kansas: Lyndon, March, 1916; November, 1915; October, 1916.
Missouri (11).

71. *R. polymorphum.* var. *sigmoideum* Rab. Plate III, fig. 22.
Kansas: Burlington, April, 1916; Independence, March, 1916, December, 1915; Lyndon, March. 1916; Jewell City, October, 1916.
Nebraska (24).

72. *R. convolutum* (Corda) Rab. (*A. convolutus* Corda). Plate III, fig. 21.
Kansas: Douglas, August, 1915; Cherryvale, December, 1915; Coffeyville, November, 1915.
Iowa (4); Nebraska (24).

2. *Scenedesmus.*

Key to Species.

I. Ends of cells acute, colonies of 4-8 cells, 5-27 by 3-9 mic. *S. obliquus.*

II. Ends of cells rounded, terminal cells of series with long projections, colonies of 2-8 cells, arranged in a single series or in two alternating rows ..... *S. quadricauda.*

73. *S. obliquus* (Turp) Kuetz. (*S. acutus* Nägeli). Plate III, fig. 24.
Kansas: Leavenworth, July, 1916.
Iowa (4); Nebraska (24); Missouri (11); Colorado (15).

74. *S. obliquus* var. *dimorphus* (Turp) Hansgirg.
Kansas: Lyndon, November, 1915, October, 1916; Paola, July, 1916.
Colorado (15); Iowa (4); Nebraska (24); Missouri (11).

75. *S. quadricauda* (Turp) Brebisson; (*S. caudatus*) Wolle.
Kansas: Atchison, August, 1915; Douglas, August, 1915; Waconda Springs, July, 1916; Garnett, August, 1916; Cherryvale, October, 1916.
Iowa (4); Missouri (11-9).

76. *S. quadricauda* var. *typicus* Kirchner. Plate III, fig. 23.
Kansas: Osawatomie, August, 1915.
Nebraska (24); Colorado (15).

3. *Coelastrum.*

Key to Species.

I. Cells united by quite short processes, interspaces much smaller than diam. of cell.

A. Cells 5-12 mic. in diam. and somewhat lobed with truncate projection at the middle ..... *C. cambricum.*

B. Cells 6-16 mic. in diam., spherical and united by the gelatinous surfaces ..... *C. microporum.*

77. *C. cambricum* Archer.
Kansas: Washington, August, 1916, July, 1916.

78. *C. microporum* Nägeli.
Kansas: Douglas, August, 1915.
Missouri (11).

4. *Dictyosphærium.*

79. *D. Ehrenbergianum* Nägeli. Plate III, fig. 25.
Kansas: Parsons, August, 1915, December, 1915; Paola, August, 1915; Lyndon, November, 1915; Coffeyville, July, 1916.
Missouri (11).

Family III. Hydrodictyaceæ.

The only genus of the Hydrodictyaceæ found was Pediastrum.

Key to Species.

I. Lobes of marginal cell simple, disk perforate ..... *P. duplex.*

II. Lobes of marginal cell imarginate, bidentate or bifid, disc continuous ..... *P. tetras.*

80. P. duplex Meyen; (*P. pertusum*) Wolle. Plate III, fig. 26.
Kansas: Douglas, August, 1915; Mound City, August, 1915; Yates Center, August, 1915; Coffeyville, July, 1916.
Missouri (11); Colorado (15).

81. P tetras (Ehrbg.) Rolfs; (*P. Ehrenbergii*) A. Braun.
Kansas: Burlingame, October, 1916.
Iowa (4); Missouri (11); Colorado (15).

ORDER IV. *ULOTRICHALES.*

Key to the Families of Ulotrichales.

I. Chromatophore net-, disk-, or band-shaped.
  A. Fronds unbranched filaments; sexual reproduction by isogamous gametes ..... *Ulotrichaceæ.*
  B. Fronds branched or simple.
    * Sexual reproduction by oogonia and antheridia; chromatophores net-shaped; filaments erect..... *Œdogoniaceæ.*
    * * Sexual reproduction by isogamous zoögametes; fronds filamentous usually with hairs ..... *Chætophoraceæ.*

Family I. ULTRICHACEÆ.

Key to the genera of Ulotrichaceæ.

A. Filaments monosiphonous throughout, cells forming a cylindrical filament.
  * Cells without pyrenoid, chromatophore a granular sheath covering the wall more or less completely.....1. *Microspora.*
  * * Cells with one or more pyrenoids, chromatophore a zonate band sometimes incomplete.....2. *Ulothrix.*

1. *Microspora.*

82. M. stagnorum Kuetz. Lagerheim.
Kansas: Olathe, August, 1915, November, 1915, April, 1916, in masses along with *Microthamium Kuetzingianum*, July, 1916.
Iowa (4). Missouri (11).

2. *Ulothrix.*

83. U. tenerrima Kuetz.
Kansas: Washington, April, 1916, mixed with *Conferva minor.*
Iowa (4); Colorado (15); Nebraska (3).

Family II. ŒDOGONIACEÆ.

Œdogonium was the only genus of the Œdogoniaceæ found.

84. Oe. irregulare Wittrock. Plate IV, fig. 30.
Kansas: Douglass, June, 1916, great fruiting masses.

85. Oe. ———*sp.?*
Kansas: Leavenworth, July, 1916.

86. Oe. ———*sp.?*
Kansas: Jewell City, November, 1915, August, 1915, October, 1916.

87. Oe. ———*sp.?*
Kansas: Medicine Lodge, August, 1915.

Family III. CHÆTOPHORACEÆ.

Key to the genera of Chætophoraceæ.

A. Fronds erect with differentiated base and apex.
  * Fronds less than 1 mm. high, tips not acute nor setiferous 1. *Microthamnion.*
  * * Fronds larger, tips generally acute or setiferous, filaments practically free.
    a. Fascicled ramuli different in character from stem. 2. *Draparnaldia.*
    b. Stem, branches, and ramuli little differentiated 3. *Stigeoclonium.*

1. *Microthamnion.*
   88. M. Kuetzingianum Nägeli.
   Kansas: Olathe, April, 1916.
   Nebraska (3); Missouri (11).
2. *Draparnaldia.*
   89. D. glomerata (Vauch) Agardh. Plate IV, fig. 27.
   Kansas: Neodesha, November, 1915.
   Nebraska (25); Colorado (15).
3. *Stigeoclonium.*

Key to Species.

I. Opposite branching predominant; filaments 11-30 mic. in diam; lower cells usually longer than broad; ramuli sharp-pointed *S. lubricum.*

II. Alternate branching predominate, filaments short, tufted, 7-9 mic. in diam., ramuli scattered, tips setiferous.....*S. æstivale.*

90. S. lubricum (Dilliv.) Kuetz.
Kansas: Atchison, November, 1915.
Missouri (11).

91. S. æstivale Hazen. Plate IV, fig. 28.
Kansas: Galena, December, 1915, April, 1916.
Missouri (11).

ORDER V. SIPHONOCLADIALES.

The only family of the Siphonocladiales in the reservoirs was the Cladophoraceæ of which Cladophora was the only genus found.

1. *Cladophora.*

Key to Species.

I. Fronds permanently attacked to substratum.
  A. Ramuli in dense terminal clusters straight or slightly curved.
    1. Lower branching mostly dichotomous; branches connate for some distance; main filaments 85-120 mic. in diam. *C. canalicularis.*
    2. Branching mostly alternate; branches not connate, 75-100 mic. in diam .....*C. glomerata.*
  B. Ramuli not in dense terminal clusters.
    1. Frond not over 1 cm. high; filaments about 40 mic. in diam. *C. uberrima.*
    2. Frond larger, 10-40 cm. high; filaments 75-125 mic. in diam. *C. callicoma.*

92. C. canalicularis (Roth) Kuetz.
Kansas: Independence, December, 1915.
Nebraska (24); Missouri (11).

93. C. glomerata Kuetz. Plate IV, fig. 29.
Kansas: Mound City, August, 1915.
Missouri (9); Colorado (15); Nebraska (24-25); Iowa (4).

94. C. Uberrima Lambert.
Kansas: Burlingame, November, 1915, October, 1916.

95. C. callicoma Kuetzing.
Kansas: Horton, June, 1916.

96. C.———sp.?
Kansas: Council Grove, November, 1915.

97. C———sp.?
Kansas: Medicine Lodge, August, 1915.

CLASS V.

BACILLARIEÆ or Diatoms include a very large number of unicellular plants. They have beautifully marked siliceous cell-walls, the marks being constant in size and arrangement for each species; cell constructed in two parts (*valves*) one overlapping the other in the manner of a pill box; a longitudinal cleft (*raphe*) which runs from end to end is a series of openings through which pseudopodia are thrust for locomotion. The cells contain a central nucleus swung in cytoplasm and two or more brown-greenish-yellow chromoplasts. "In cell division the growth of the protoplast separates the valves and division occurring in the plane of the valves, each new protoplast possesses one of the old valves and forms a new valve on the naked side." (8*a*) It has been estimated that there are over ten thousand species of Diatoms.

Key to the Subfamilies of Bacillarieæ.

I. Valves with a concentric or radiating structure around a central point; without raphe; valve view circular or broadly elliptical. *Centricæ.*

II. Valves never concentric, mostly broad-shaped, with a raphe. *Pennatæ.*

Subfamily I. CENTRICEÆ.

The Discoideæ is the only tribe of the Centricæ which has representatives in our Kansas reservoirs, Melosira being the genus identified. Melosira is characterized by frustules with circular, very wide connective bands, attached valve to valve forming long cylindrical filaments.

98. Melosira Agardh. Plate IV, fig. 31.
Kansas: Burlington, April, 1916; Emporia, April, 1916; Horton, June, 1916.
Nebraska (25-2); Iowa (4).

Subfamily II. PENNATÆ.

Key to the Tribes of Pennatæ.

I. Cells mostly straight, rod shaped or lanceolate, without a raphe but sometimes with pseudoraphe ..... *Fragilarioideæ.*

II. Cells crooked or suddenly bent, with a raphe on one valve and a pseudoraphe on the other ..... *Achnanthoideæ.*

III. Cells with a raphe on each valve ..... *Naviculoideæ.*

IV. Cells with the raphe concealed in submarginal wings of each valve. *Surirelloideæ.*

Tribe I. *Fragilarioideæ.*

Key to the genera of Fragilarioideæ.

I. Frustules elongated, straight or slightly curved, united at base in fan-shaped clusters; usually straight with almost parallel sides, transversely striated and mostly with pseudoraphe.....*Synedra.*

II. Frustules attached side by side into a ribbon; valves elongated with lanceolate ends; frustules in girdle view rectangular and in contact with each other entire length.....*Fragilaria.*

99. *Synedra* Ehrbg. Plate IV, fig. 38.
Kansas: Widely distributed, found over twenty times.
Nebraska (2-3-24-25); Iowa (4).

100. *Fragilaria* Lyngby. Plate IV, fig. 33.
Kansas: Douglass, August, 1915; Independence, April, 1916; Horton, June, 1916; Paola, July, 1916.
Nebraska (1-2-24-25); Iowa (4).

Tribe II. *Achnanthoideæ.*

Cocconeis, the only genus of the Achnanthoideæ thus far identified; frustules of the valves unlike; valves broadly oval.

101. *Cocconeis* Ehrbg. Plate IV, fig 37.
Kansas: This genus was found at Cedarvale in August, 1916.
Nebraska (2-24-25); Iowa (4).

Tribe III. *Naviculoideæ.*

Key to the genera of Naviculoideæ.

I. Frustules symmetrical, valves boat-shaped; marked with transverse furrows having a slight radial tendency; some long and narrow and some short and wide; ends either pointed or rounded. *Navicula.*

II. Very similar to Navicula, frustules rectangular in girdle view. A narrow clear space along the raphe and a wider transverse clear space at the medial nodule extending to the sides of the valve gives the valves a marking having the appearance of a cross. *Stauroneis.*

III. Frustules much the same as Navicula, but with axis turned like a letter S. Raphe sigmoidal .....*Pleurosigma.*

IV. Frustules borne on pedicels more or less branched. Valves bilaterally symmetrical, wedge shaped with central nodule near the large end .....*Gomphonema.*

V. Frustules elongated symmetrical with respect to the minor axis. Valves with one side very convex and the other side hardly at all convex, surface transversely striated.....*Cymbella.*

VI. Frustules, when young, enclosed in a mucilaginous tube, in which they multiply by division; valves more or less cymbiform; a straight raphe divides the valves into two unequal parts. *Encyconema.*

VII. Frustules ovoidal to rectangular in girdle view. Valves extremely unsymmetrical with a convex and concave side, an eccentric raphe, etc. The transverse striæ radiate somewhat from the median nodule .....*Amphora.*

VIII. Frustules free, elongated, valves linear, pointed; surface punctate or transversely striate.....*Nitzschia.*

102. *Navicula.* Bory. Plate IV, fig. 36.
Kansas: Very widely distributed, having been found eighty-five times.
Nebraska (1-2-3-24-25); Iowa (4).

103. *Stauroneis* Ehrbg.
Kansas: Cedarvale, August, 1916.
Nebraska (1-2-3-24-25); Iowa (4).

104. *Pleurosigma* W. Smith. Plate IV, fig. 35.
Kansas: Found eleven different times during the survey.
Nebraska (1-2-3-24-25); Iowa (4).

105. *Gomphonema* Agardh.
Kansas: Cherryvale, 1915; Mound City, August, 1915; Medicine Lodge, August, 1915; Burlingame, November, 1915, October, 1916; Jewell City, November, 1915; Horton, June, 1916.
Nebraska (1-2-3-24-25); Iowa (4).

106. *Cymbella* Agardh. Plate IV, fig. 34.
Kansas: Rather generally distributed. Identified about 25 times.
Nebraska (1-2-3-24).

107. *Encyonema* Agardh. Plate IV, fig. 32.
Kansas: Waconda Springs, July, 1916; clinging together in gelatinous masses extending into filaments.
Nebraska (2).

108. *Amphora* Ehrbg.
Kansas: Identified ten different times.
Nebraska (1-2-24); Iowa (4).

109. *Nitzschia* Hassall.
Kansas: Chanute, November, 1915; Cherryvale, November, 1915; Independence, December, 1915; April, 1916; Ottawa, November, 1915; Burlington, April, 1916; Council Grove, April, 1916; Horton, April, 1916.
Nebraska (1-2-3-24-25); Iowa (4).

Tribe IV. *Surirelloideæ.*

110. *Surirella* (Turpin).
Oval valves with conspicuous transverse tubular striæ between which are sometimes very pearled striæ; wide pseudoraphe.
This genus was found only three times, *i. e.*, Kansas: Chanute, November, 1915; Council Grove, April, 1916; Emporia, April, 1916.
Nebraska (24): Iowa (4).

Table III.—Seasonal Distribution and Frequency of the Genera of Algæ.

Genus	Summer 1915	Winter 1915	Spring 1916	Summer 1916	Winter 1916	Total
Myxophyceæ						
Anabaena			1	3		4
Clathrocystis	1	2	4	1		8
Gleocapsa				1		1
Hypheothrix			1			1
Lyngbya	6	8	10	9	9	42
Merismopedium	1	1	1	1	2	6
Microcoleus	1	1				2
Nostoc		1		1		2
Oscillatoria	30	17	21	10	13	91
Phormidium		1		1		2
Spirulina	3	1		1	3	8
Total						167
Flagellata						
Dinobryon	1					1
Euglena	1	1		2	1	5
Total						6
Heterokontæ						
Conferva	4	3	7	1		15
Ophiocytium	2					2
Total						17
Chlorophyceæ						
Botryococcus			1			1
Characium				2		2
Chlamydomonas	3	2	2		1	8
Cladophora	2	3		1	1	7
Closterium	1	1		1	1	4
Coelastrum	1			2		3
Cosmarium	4	1	1	2	3	11
Dictyosphaerium	2	2	1			5
Draparnaldia		1				1
Microspora	1	1	1	1		4
Microthamium			1			1
Mouge tia	1	1	1	3		6
Oedogonium	2	1		2	1	6
Pandorina		2	2	2	2	8
Pediastrum	3		1		1	5
Raphidium	1	8	5		3	17
Scenedesmus	3	1	1	3	2	10
Spirogyra		1	1	3	2	7
Stigeoclonium		2	1			3
Tetraspora			2		1	3
Haematococcus	1					1
Ulothrix			1			1
Zygnema				1		1
Total						114
Bacillarieæ						
Amphora			1	2	7	10
Cymbella	2	8	7	5	1	23
Cocconeis				1		1
Encyonema			1			1
Fragillaria	1		1	2		4
Gomphonema	3	2		1	1	7
Melosira			1	1	1	3
Navicula	19	20	23	14	9	85
Nitzschia		3	4		1	8
Pleurosigma	3	3	2		3	11
Stauroneis				1		1
Surirella		1	2			3
Synedra	5	5	10	2	3	25
Total						182
No. of Genera	29	31	32	32	24	
Total of Frequency						486

Table III shows the seasonal distribution and frequency of the various genera of algæ. Although there were but thirteen genera of diatoms classified, they appeared 182 times, while the twenty-three genera of Chlorophyceæ were found only 114 times. Eleven genera of Myxophyceæ were found 167 times. The grand total indicates that the fifty-one genera of algæ appeared 486 times throughout the survey. It is of interest to note that, although the specific genera varied from season to season, the number of genera remained quite constant. During the period of my observations the season of the year did not seem to have any such relation to the species found, as Transeau (21*a*) discovered in his study of algæ of the pools and ponds of central Illinois. This may be due to the artificial conditions brought about by the chemical treatment and dredging of the reservoirs. The length of time necessary to establish such periodicity in artificial conditions might be greater than in natural conditions where observations were carried on for seven and a half years.

Of the many cases handled by the workers in the water laboratory, the following instances show the value of the copper-sulfate method of removing algæ from the reservoirs in Kansas.

In June, 1916, the water at Horton, Kan., was in bad condition, according to Supt. W. W. Wood. The author made a trip to Horton and found the water had a disagreeable odor and a dark, reddish-brown color. This color could not have been due to iron, since laboratory diagnosis had shown no iron present. The reservoir was found to be covered with a decaying mat of Cladophora, Spirogyra, Zygnema, Mougeotia, Anabæna, Closterium, Euglena and Characium. The odor of the water in the reservoir, as well as the color, was due to these decaying forms. The settling basin showed a count of sixty-eight organisms per cubic centimeter of water, forty-nine of which were Anabæna. The basin, with a capacity of 600,000 gallons of water, was treated with two and one-half pounds of $CuSO_4$ and allowed to stand for twenty-four hours. The supply of the basin was changed from the infested reservoir to the creek, whose overflow supplies the reservoir and whose waters at that time were comparatively free from algæ. In forty-eight hours all odors and color had disappeared from the water in the basin.

In the fall of 1916, the Olathe water system was infested with heavy growths of Conferva. Much of the dense entanglement was raked out upon the banks and the water was treated at the rate of six pounds of copper sulfate to a million gallons of water. The water was usable within three days.

Russell, whose impounding reservoir has a capacity of 39,000,000 gallons, was troubled in September, 1916, with heavy growths of Anabæna, Conferva and Cladophora. The lowering waters had left a carpet of decaying algæ about the edge. The reservoir was treated with 50 pounds of copper sulfate distributed from a sack at the stern of a boat, the banks were sprayed with about 100 pounds of the $CuSO_4$ in solution. No further trouble was reported.

In March, 1917, Burlington reported a bad taste to the city water and offensive odors rising especially from the filter beds. Analyses showed

the filters to be covered with numerous Synedra, Navicula, Chlamydomonas and Clathrocystis. The filters were washed, and about a foot of water, to which one pound of $CuSO_4$ had been added, was left standing in each. The basins were treated with eight pounds to the million gallons. The filters, after standing for eight hours, were drained into the sewer, and the water now let in from the basin and filtered was in good condition.

Occasionally difficulty which seems to be due to the algæ may be caused by the growth of small animals. A few cases in our state where water from the basins and filters has given off foul odors have been traced to this cause. For example, Lyndon, in May, 1917, and Kansas City, in January, 1917, reported offensive, fishy odors coming from their settling basins and filters, and that the walls were covered with a brownish-gray growth resembling masses of roots. Samples of this material analyzed in the laboratory proved to be Polyzoa, minute animals forming mosslike clusters. These small animals when in a state of decomposition give off an odor much the same as comes from a stagnant fish pond. By a purely mechanical treatment, consisting in scraping the walls and carefully cleaning the filters, the difficulty as to odors was removed. On the other hand, the State Hospital at Osawatomie, in February, 1917, when troubled by a protozoan, Vorticella, in the water supply, eradicated it by the use of copper sulfate.

Other similar cases of the successful use of copper sulfate in the water reservoirs have been recorded by the workers in the Kansas water laboratory. The method has been practically the same in all cases and the dosage and identification of the organisms have been easily made from tables and keys such as given in this report.

SUMMARY.

1. Out of the one hundred and ten species of algæ listed in this paper only twelve have been reported previously in this state; thirty-seven have not been reported in our neighboring states. Fifty-five species of the Chlorophyceæ were identified, thirty-six of the Myxophyceæ, thirteen Bacillariæ, four Hetreokontæ and two Flagellata. Fourteen species of Oscillatoria were classified. This genus was found ninety-one times and is the most common algal form prevalent in our reservoirs. The diatoms were always present, Navicula being found eighty-five times.

2. The algæ of our state which have been found to be the most active in causing bad tastes, odors or colors in our drinking water are Anabæna, Conferva, Oscillatoria, Spirogyra, Cladophora, Clathrocystis, Synedra and Navicula. Animals of the Polyozoan and Protozoan groups have also been found to cause these difficulties.

3. The collections of algæ during the five seasons brought out no changes due to the differences in the seasons. To determine whether this is due to the absence of seasonal influence on the flora or to the artificial conditions of the reservoirs requires data from a longer period of time than is covered by this paper.

4. The copper sulphate treatment for algal trouble has been used successfully in Kansas.

BIBLIOGRAPHY.

1. Bessey, C. E.; Pound, R.; Clements, F. E.; 1893. Miscellaneous Additions to the Flora of the State and New and Noteworthy Species from Various Localities. Bot. Survey of Neb. Seminar, Lincoln.
2. ———. 1896. Additions to the Reported Flora of the State. Bot. Survey of State of Neb. Seminar, Lincoln.
3. ———. 1901. New Additions to the Reported Flora of the State. Bot. Survey of State of Neb. Seminar, Lincoln.
4. Buchanan, R. E., 1908. Notes of Algæ of Iowa. Proc. Iowa Acad. of Sci. 14.
5. Calkins, G. N., 1892. A Study of Odors Observed in the Drinking Waters of Massachusetts. 24th Annual Report of St. Board of Health of Mass. p. 355. Boston.
6. Chamberlain, C. J., 1915. Methods in Plant Histology, page 163-4. Chicago.
7. Collins, F. S., 1909. The Green Algæ of North America. Tufts Col. Studies, Vol. II., No. 3. Boston.
8. Conn, Herbert W., 1908. The Algæ of the Fresh Waters of Connecticut. Bull. No. 10. Conn. Geo. and Nat'l Hist. Survey. Hartford.

8*a*. Coulter, J. M., Barnes, C. R., and Cowles, H. C., 1910. Textbook of Botany. Vol. I. Chicago.

9. Englemann Botanical Club, 1911. A Preliminary Check List of the Cryptogams and Phanerogams in the Vicinity of St. Louis, Mo. St. Louis.
10. Engler, A. and Prantl, K., 1900. Die Natürlichen Pflanzenfamilien. Vol. I, p. 31. Leipzig.
11. Hayden, Ada, 1910. The Algæ Flora of the Missouri Botanical Garden. 21st Report of Mo. Bot. Garden. St. Louis.
12. Kellerman, K. F., 1912. The Rational Use of Disinfectants and Algicides in Municipal Water Supplies. 8th Int. Cong. of Applied Chem. Vol. XXVI, p. 241. Washington.
13. Mason, W. P., 1916. Water Supply. New York.
14. Moore, G. T., and Kellerman, K. F., 1905. Copper as an Algicide and Disinfectant in Water Supplies. U. S. Department of Agric., Bu. of Plant Indus., Bul. No. 76. Washington.
15. Robbins, W. W., 1912. Preliminary List of the Algæ of Colorado. University of Colo. Studies. Vol. IX, No. 2-3. Boulder.
16. Rules and Regulations of the State Board of Health for the Collection of Samples and Analysis of Water. 1915. Topeka State Journal, p. 2.
17. Powell, S. T., 1914. Some observations on the Effect of Ozone on Algæ Growths. Jr. of A. Water W. A., Vol. I, No. 3, S. 629, Baltimore.
18. Smyth, B. B., 1912. Provisional Catalog of the Flora of Kansas. Trans. Kan. Acad. of Sci. Vol. XXV, p. 63. Topeka.
19. Stokes, A. C., 1893. Fresh Water Algæ and the Desmidiæ of the United States. Trenton, N. J.
20. Tilden, Josephine, 1910. Minnesota Algæ, Vol. I. Report of the Survey of Bot. Series VIII. Minneapolis.
21. Toni, G. B. de, 1889. Sylloge Algarum omnium huscusque cogitarum, Vol. 1. Padua.

21*a*. Transeau, E. N., 1916. The Periodicity of Fresh Water Algæ. Amer. Jour. of Bot., 3:121-133.

22. Van Heurck, Henri. 1880. Synopsis des Diatomees de Belgique. Copenhagen.

23. Wailes, G. H., 1912. Some Desmids from Alpine Stations in Colorado. Univ. of Colo. Studies, Vol. IX, No. 2-3. Boulder.

24. Webber, H. J., 1889. Catalogue of the Flora of Neb. Report of the Neb. State Board of Agric. Lincoln.

25. Webber, H. J., and Bessey, C. E., 1892. Appendix to the Catalogue of the Flora of Nebraska, with a Supplement of Recently Reported Species. Cont. from Bot. Dept. of Univ. of Neb. Lincoln.

26. Whipple, G. C., 1914. The Microscopy of Drinking Water. Cambridge.

27. Wolle, F. W. 1886. Fresh-water Algæ of the United States. Bethlehem.

28. ——— 1884. First Contribution to the Knowledge of Kansas Algæ. Bull. Washburn Lab. of Nat'l Hist., Vol. I, No. 1. Topeka.

29. ——— 1885. Second Contribution to the Knowledge of Kansas Algæ. Bull. Wash. Lab. of Nat'l Hist., Vol. I, No. 2. Topeka.

30. ——— 1886. Third Contribution to the Knowledge of Kansas Algæ. Bull. Wash. Lab. of Nat'l Hist., Vol. 1, No. 6. Topeka.

31. ——— 1889. Fourth Contribution to the Knowledge of Kansas Algæ. Bull. Wash. Lab. of Nat'l Hist., Vol. II, No. 9. Topeka.

These drawings were made by the aid of the camera lucida.

PLATE II.

Fig.	1.	Gleocapsa arenaria	× 750
Fig.	2.	Merismopedium glaucum	× 520
Fig.	3.	Oscilliatoria tenuis	× 750
Fig.	4.	Oscilliatoria amphibia	× 750
Fig.	5.	Oscilliatoria brevis	×1000
Fig.	6.	Spirulina major	× 750
Fig.	7.	Lyngbya putealis	× 400
Fig.	8.	Hypheothrix coriaceæ	×2200
Fig.	9.	Anabæna variabilis	× 750
Fig.	10.	Anabæna flos-aquæ	× 750
Fig.	11.	Dinobryon setularia	× 750
Fig.	12.	Euglena viridis	×1500
Fig.	13.	Conferva utriculosa	× 600

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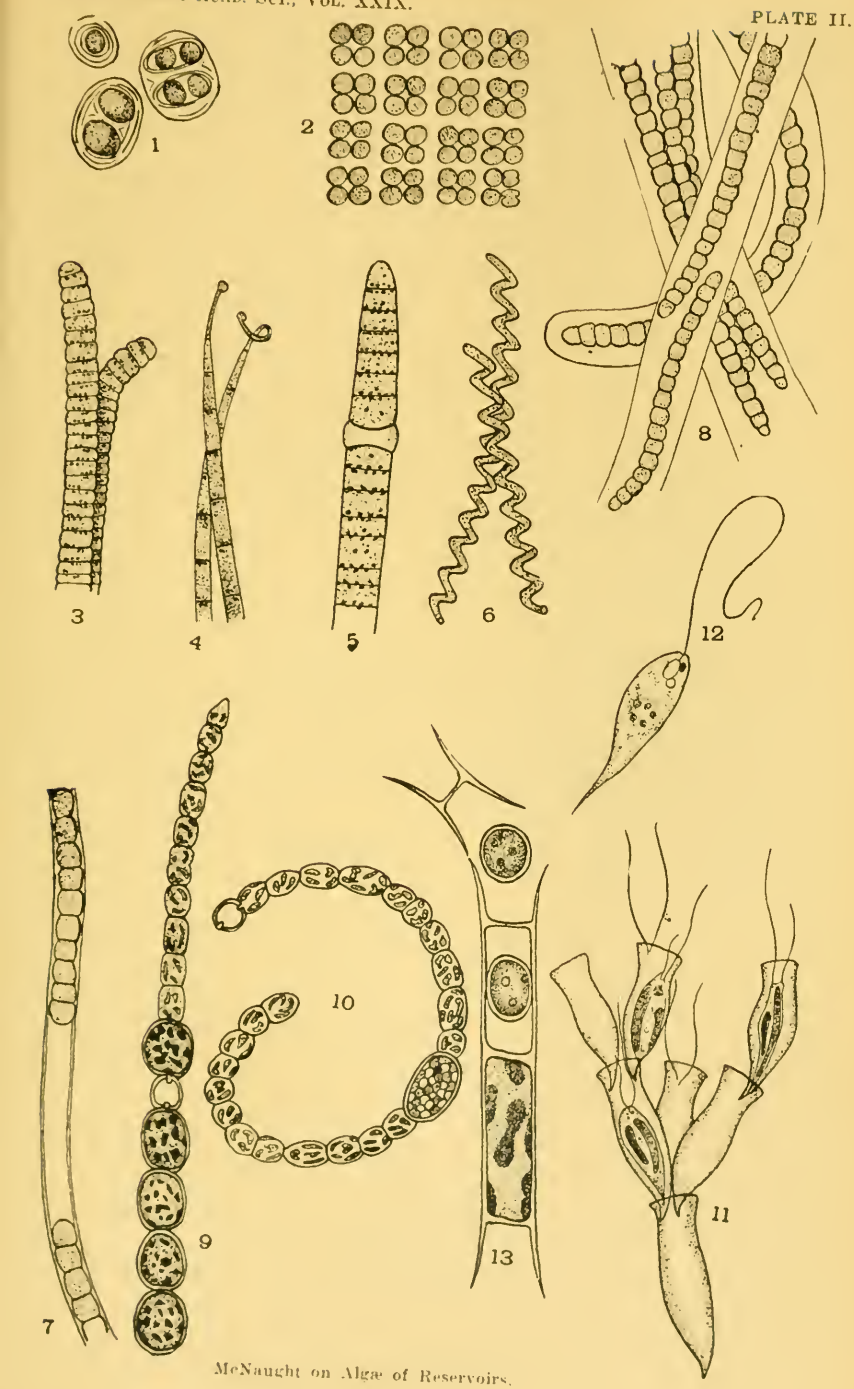
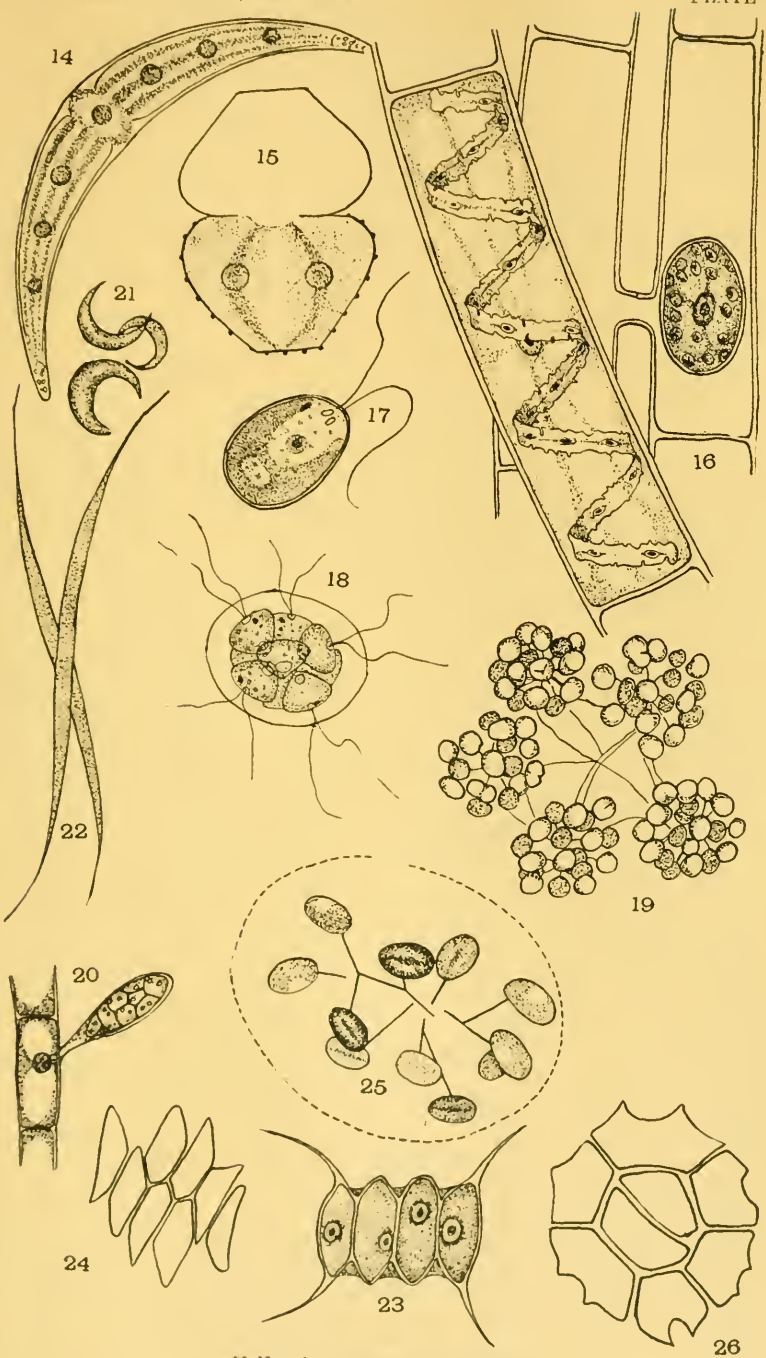
PLATE II.



McNaught on Algæ of Reservoirs.

PLATE III.

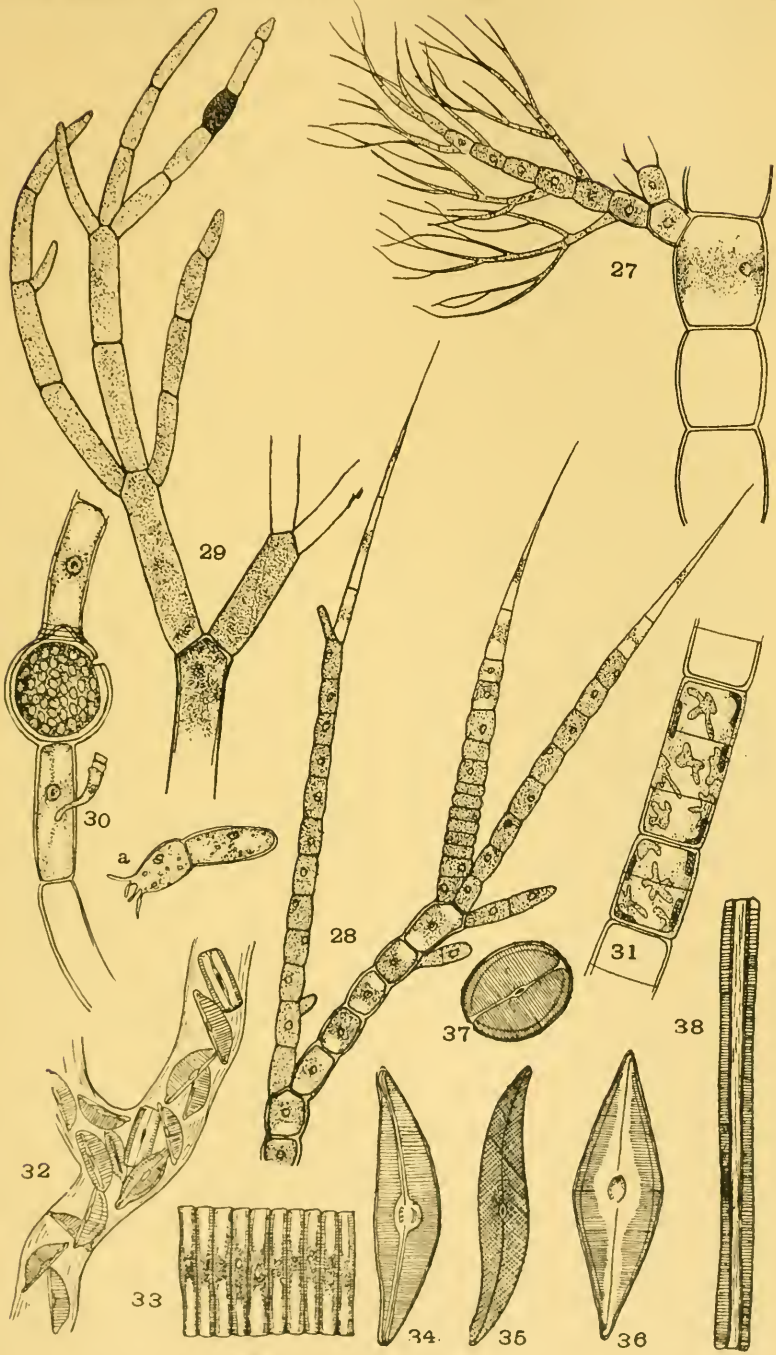
Fig. 14.	Closterium Dianæ	× 800
Fig. 15.	Cosmarium Botrytis	× 520
Fig. 16.	Spirogyra longata	× 520
Fig. 17.	Chlamydomonas communis	×1500
Fig. 18.	Pandorina Morum	× 300
Fig. 19.	Botryococcus Braunii	× 450
Fig. 20.	Characium Nægelii	×
Fig. 21.	Rhaphidium convolutum	× 750
Fig. 22.	Rhaphidium polymorphum var. sigmoideum	× 520
Fig. 23.	Scenedesmus quadricauda var. typicus	×1200
Fig. 24.	Scenedesmus obliquus	×1200
Fig. 25.	Dictyosphærium Ehrenbergianum	×1200
Fig. 26.	Pediastrum duplex	



McNaught on Algæ of Reservoirs.

PLATE IV.

Fig. 27.	Draparnaldia glomerata	× 520
Fig. 28.	Stigeoclonium æstivale	× 520
Fig. 29.	Cladophora glomerata	× 375
Fig. 30.	Œdogonium irregulare	× 300
Fig. 30*a*.	Œdogonium, small plant	× 300
Fig. 31.	Melosira	× 500
Fig. 32.	Encyonema	× 600
Fig. 33.	Fragilaria	× 500
Fig. 34.	Cymbella	× 400
Fig. 35.	Pleurosigma	×
Fig. 36.	Navicula	×
Fig. 37.	Cocconeis	×
Fig. 38.	Synedra	×



McNaught on Algæ of Reservoirs.

Correlation of the Formations Described in the Fort Apache Region in Arizona with Similar Formations in Other Parts of the State.

ALBERT B. REAGAN.

On page 152 of Professional Paper 98-K of the U. S. Geological Survey, Dr. Frederick Leslie Ransome says, in speaking of my work in the Canyon creek section[1] (Arizona), that attempts to identify in my published sections the formations discriminated in the Roosevelt and Grand Canyon sections have met with little success.[2]

As my field work as well as Gilbert's was done before anything much was really known of the geology of that part of Arizona, the sedimentary rocks were mapped and described in groups, as it then appeared impracticable to map them in as great detail as has since proved possible in the Ray quadrangle, for instance. Furthermore, on account of the advanced knowledge of the geology of the entire region, certain peculiar formations which were then difficult to identify can now be readily placed by comparing them with stratagraphic work in other sections.

The following sections of the Palæozoic strata of Arizona from Mexico to the Grand Canyon have been made:[3] Bisbee,[4] Tombstone,[5] Clifton,[6] Globe and Ray Quadrangles,[7] Roosevelt,[8] Southern,[9] Part of the Sierra Ancha,[10] Northern Part of the Sierra Ancha,[11] Head of Canyon Creek,[12] Jerome region,[13] and Grand Canyon.[14]

By a comparison of these sections it is easily seen that Gilbert did not see the entire Cambrian series at Canyon creek and that his Tonto Sandstone, as with my sections, is the upper part of the series. His section at the head of Canyon creek was often visited by the writer, and from appearance all he examined at this point was the Dripping Spring quartzite and the Barnes conglomerate; the rest of the series is wanting at this point and the Dripping Spring quartzite is in itself not its full thickness. Gilbert's section is on the crest of the east and west older pre-cambrian ridge that underlies the Palæozoic here and now extends as the surface rock from near Ellison P. O. westward through the Tonto basin, covering a region from five to fifteen miles wide. In mapping the formation the writer followed Gilbert and considered the formation below the Barnes conglomerate as Algonkian. But in the light of later investigations it is the lower part of the Cambrian series and is included in the Tonto group of Noble's Grand Canyon section. Several miles down Canyon creek from where Gilbert took his measurements the Pioneer shale comes to view beneath the Barnes conglomerate. The

1. Reagan, A. B., Geology of the Fort Apache region in Arizona. Am. Geologist, vol. 32, pp. 265-308, 1903.
2. Ransome, Professional Paper 98-K of the U. S. Geological Survey, p. 152.
3. Ransome, Professional Paper 98-K, plate XXV.
4. Ransome, F. L., U. S. Geological Survey, Paper 21, 1904.
5. Ransome, F. L., from unpublished data.
6. After Lingren, W., U. S. Geological Survey, Folio 129, 1905.
7. Ransome, F. L., Washington Academy of Sciences Journal, vol. 5, pp. 380-388, 1915.
8. Ransome, F. L., from unpublished data.
9. Ransome, F. L., from unpublished data.
10. Ransome, F. L., from unpublished data.
11. Gilbert, G. K., Wheeler Survey, vol. 3, pp. 163-164, 1875.
12. Ransome, F. L., from unpublished data.
13. Based chiefly on work of L. F. Noble, U. S. Geological Survey, Bulletin 509, plate X, 1914.

writer's Algonkian formation includes the Pioneer shale and the Scanlon conglomerate and the Tapeats sandstone which lies between the shale and the conglomerate in a few places. It should also be added that as one approaches the Sierra Ancha the Tonto group undergoes slight changes and many variations are noticed which only careful study of detail work will straighten out. The writer's Tonto Sandstone group in the Apache mountains is the Apache group of the Globe quadrangle with the addition of the Troy quartzite and Mescal limestone, all of which are Cambrian in age. Carboniferous and Devonian rocks also occur in the Apache mountains but were not mapped, though their presence is noted in the Nantan Mountains.

In correlation, the Apache group in the Globe quadrangle, from base up, includes the Scanlan conglomerate, Pioneer shale, Barnes conglomerate and Dripping Spring quartzite. Devonian and Carboniferous limestone were also mapped in that region, as the "Globe limestone" along with which was mapped the Mescal limestone in many places. The Abrigo limestone of Bisbee and Tombstone is an equivalent of the Longfellow formation of Clifton, the Mescal limestone of the Globe-Ray quadrangle and at Roosevelt and in the southern part of the Sierra Ancha (the Troy quartzite of the Globe-Ray region—400 feet thick—is the white quartzite—8 feet thick—at the top of the Abrigo at Bisbee), and the Mauv limestone (formerly included in the Tonto shale) and the Bright Angel shale together of the Grand Canyon section. In this paper it will be considered as the Mescal limestone. The Tapeats or Tonto quartzite (sandstone) is an equivalent of the Bolsa quartzite of the Bisbee and Tombstone sections, the Coronado quartzite of Clifton, the Dripping Spring quartzite (or the Dripping Spring quartzite, Barnes conglomerate, Pioneer shale and Scanlan conglomerate) of the Globe-Ray quadrangle and Roosevelt region and the southern part of the Sierra Ancha.[14] Below is my section "From Farmer's residence on Cibicu to Salt Springs on Salt river, near its confluence with Canyon creek,"[15] compared with the "Globe and Ray quadrangles."[16]

14. See Ransome, F. L., Professional Paper 98-K of the U. S. Geological Survey, pp. 143, and 164-166, and plate XXV.

15. Reagan, A. B., Geology of the Fort Apache region in Arizona. Am Geologist, vol. 32, pp. 273-274.

16. Ransome, F. L., loc. cit., plate XXV.

Section from Farmer's residence on Cibicu to Salt Springs on Salt river near its confluence with Canyon creek.

UPPER RED WALL GROUP (NOW SUPAI).

1. Alternating limestone and sandstone (*Productus cora, Spirifer, cameratus, Calamites cannaeformis*). 60 to 120 feet.

2. Millstone grit, calcareous sandstone shaly to massive. 20 feet.

LOWER RED WALL GROUP (NOW RED WALL).

3. Alternating gray limestone and shale varying in color from black to red (*Orthis pornata, Orthis livia, Spirifer fornicula, S. striatus, S. preëxtensus, S. Plenus, Orthonata paralleta Lithostration californiense, Chonetes dalmania*). 400 feet

Section from the Globe and Ray quadrangles.

TORNADO LIMESTONE.
1,000 feet.

Thick beds of light-gray limestone. Fossils scarce in lower or Mississippian portion, but plentiful in the Pennsylvanian portion.

No recognizable plane of division between Mississippian and Pennsylvanian.

DEVONIAN (NOW MARTIN LIMESTONE). 4. Alternating chert and flint strata. 40 feet. 5. Massive light colored marbled limestone (*Acervularia davidsoni abundant*). 35 feet. 6. Stratum of grit rock. 15 feet.	MARTIN LIMESTONE. 325 feet. Generally pebbly cross-bedded quartz- upper half. Gritty base. Shale at top.
SILURIAN. 7. Red to brown fossiliferous limestone (*Orthis davidsoni, Strombodes pentagouis*). 65 feet.	
TONTO FORMATION. 8. Massive to shaly, brown to red, coarse, cross-bedded vitreous sandstone. 600 feet. 9. Red, cleavage-jointed shales. 40 feet. 10. Gray to red sandstone, falling apart in angular blocks. 70 feet.	APACHE GROUP. TROY QUARTZITE. 400 feet. Generally pebbly cross-bedded quartzite with lenses of conglomerate. Shaly, rusty beds with worm casts at top.
11. Marbles, limestone (marbled limestone). 70 feet.	Vesicular basalt flow. 25-75 feet. MESCAL LIMESTONE. 225 feet. Thin, varicolored, more or less dolomite beds with cherty layers.
12. Vitreous to soft, red purple, green and white sandstone and shale, a conglomerate completing the series. 150 feet.	DRIPPING SPRING QUARTZITE. 450 feet. Fine-grained varicolored arkosic quartzite, much of it with dark red and gray banding partings between the beds not distinct. Ripple marks. BARNES CONGLOMERATE. 10-55 feet.
13. Hornblende biotite granite and olivine diabase (intrusive) and dioryte (a sill). 120 feet. 14. Vitreous, soft, red, purple, green and white sandstone and shale. 300 feet.	PIONEER SHALE. 150 feet. Maroon shale, arkosic and quartzite near base.
15. Conglomerate. 10 feet. Great unconformity.	SCANLON CONGLOMERATE. 0-15 feet. Great unconformity.
ARCHÆAN. 16. Gneiss. 100 feet. 17. Granite and allied rocks. 600 feet.	OLDER PRE-CAMBRIAN.

The correlation shows that the formations of the Globe and Ray quadrangles and those of Canyon creek are identical.

ALBERT B. REAGAN,
Ex-principal of the Southern Ute Boarding School, Ignacia, Colo.

March 15, 1918.

The Mine Centre Mining District, Ontario, and Adjacent Territory in the United States.

ALBERT B. REAGAN.

Recently the writer visited the Mine Centre district and was much impressed by what he found there. In the old days the country was so wooded that prospecting was a very difficult proposition, but now, that the fire of some years ago stripped the country of all vegetation, every ledge and vein is visible and the prospector will have no difficulty in finding good ore outcrops, if such are in the region, as facts demonstrated they are. The region is a gold country, as is well known. The ore seems to be found in ledges and veins of quarts protruding up through the Kewatin series. A small vein just west of the depot at Mine Centre, a vein not thicker than my hand, showed free gold, and almost any vein in that region, however thin, carries some gold.

This was a great mining center in the latter part of last century. But in that time it was terribly handicapped on account of the inaccessibility of the region. There was no railroad then and all supplies had to be hauled 100 miles through an almost trackless wilderness in winter. In addition, those who opened the mines expected to find high-grade ores in quantity. The Canadian Northern Railroad having been built through the region and the improved methods by which low-grade ores can be handled at a profit now make mining in the district profitable. Mining under experienced and economical management will pay in this district.

Even with the railroad running through the region, the mines are yet much handicapped, as roads are not built to the mines, or if built need to be much improved. The Foley mine is putting in a telephone line to Mine Centre and to offset its poor road the management contemplates putting in a large gasoline boat to ply on Rainy Lake between the mine and Fort Frances, Ont. Furthermore, if the road is not made passable by the government from Mine Centre, the company will have its coal hauled by barge from Ranier to the stamp mill for fuel instead of hauling it out from Mine Centre.

There has been an awakening in a political way recently for the benefit of this mining country. The head geologist of Canada is speaking for the region. Captain H. A. C. Machin declared recently on the floor of the provincial parliament that this part of Ontario rejoiced in mineral wealth. Politically, industrially and financially, a new regime promises justice and the mining of the region will take on new and vigorous life. Below are some of the mines of the region. Golden Crescent, Lucky Coon, Ferguson, Old Golden Star, Calm Lake Mines, Steep Rock, Elizabeth, Olive and Foley. The last five will receive more notice:

Calm Lake.—The mines in this vicinity are owned by the Calm Lake Gold Mining Company. This company has a shaft down 85 feet. At a depth of 75 feet this shaft cuts a system of veins. At this point a crosscut of 50 feet has been made to intersect the veins and make them workable. A vein known as "No. 2" was also cut through and was found to be 50 feet wide. It showed some free gold but not an entirely free

quartz. A vein dubbed "No. 3" is also expected to be cut through soon. At the surface it is wide and shows up well. Camps were recently built on the ground owned by this company. A steam hoisting plant is also in operation and everything is in good shape for extensive exploration and developing.

The Olive Mine.—A company is preparing to reopen this mine and had considerable preliminary work done when the writer visited the region. But no actual work on the mine had been done. It is one of the old and paying mines of the old times and will need considerable overhauling.

Steep Rock.—A company composed of Thomas Rawn and associates are doing diamond drilling work on iron properties here and report has it that some very good results have been obtained. Gold prospecting is also going on in the vicinity.

Elizabeth.—This is one of the old mines and was a payer. It was owned by Alan Sullivan. Considerable work was done on it, a ten-stamp mill was installed and good camp buildings erected. The mine is on Harold Lake. Mr. Sullivan had a fine log house built there for himself, had a fine fireplace built in it, had his floors covered with oriental rugs and had his walls decorated with the paintings of the old masters. But the mine failed and a Canadian bank took it to satisfy loans that had been advanced on the property. But with the coming of new life to the region, a Mr. A. McKinnon bought the mine of the bank and has been developing it. He had fifteen men employed when I visited it, and stated that he had secured some very fine ore.

The Foley.—This set of mines are located on Shoal Lake, under the management of the Foley Gold Mines Company, ltd. This company intends putting in a large garden this year to offset the cost of supplying its camp. It also expects to clear more ground near it for future use in the same line. Vegetables do well in that section and fresh vegetables will help make the table more palatable. New quarters and more commodious ones are to be erected for the accommodation of the employees. The mine is one of the old mines and has a stamp mill and other heavy machinery at hand. Also, ores to the northward from the Lucky Joe, another shaft of this group, are found to be very heavy in iron sulphides. When last stamped it is reported that the iron sulphate concentrates assayed $7.73 per ton. The free milling quartz ores from the vein also ran $20 per ton per ore handled. A shaft will also be sunk on the galena vein. Ore from this vein taken in a pit 17 feet beneath the surface assayed $30 per ton in gold, $3.58 in silver and 5 per cent in lead, but the veins in each case were thin.

At the south shaft, owned by the Foley Mining Company, much dead work has been done. The shaft has been sunk 200 feet. From this, then, a cross-cut has been driven eastward 325 feet. This cross-cut has cut four veins from five to eight feet in width and a fifth very rich vein 17 inches in width.

MINING OPERATIONS IN THE NORTHERN PART OF ST. LOUIS AND KOOCHICHING COUNTIES, MINNESOTA, ACROSS RAINY LAKE FROM MINE CENTER, ONTARIO.

The region covered by the above title is what might be termed a wholly unexplored region, so far as mining is concerned. Its country

rocks are granites, porphries, and Laurentian and Huronian rocks and volcanics and over these are superimposed glacial drift from a few inches to several hundred feet in depth. In addition, the region is often swampy, is trailless and a variable jungle. Notwithstanding this, some mining work is in prospect.

Near Gheen, on Patrick Calahan's homestead, there is a brown stained quartz ledge running in a northeast-southwest direction. It is 400 feet in width and shows 3,000,000 tons of quartz in sight. An assay of occasional small seams in this rock gives $10, $20.60, $80, and even $120 per ton. Some drilling has been done in the region, and good findings have been reported.

A quartz ledge similar to the above is also exposed on Finlander Hill, north of Gheen, showing gold.

IRON ORE NEAR RAY, MINN , AND FORT FRANCES, ONT.

Iron ore has been discovered in large bodies both at Ray, Minn., and at Fort Frances, Ont. A wide belt of the iron formation extends in a north and south direction and is mostly continuous on both sides of the International Boundary line. Companies have been formed both at Ray and at Fort Frances and drilling and prospecting has been done. The ore strip is found about three miles west of Ray and to the north of Fort Frances, though it is believed that the formation is continuous. The drill showings are good.

PLACER MINING NEAR KINMOUNT, MINN.

West of Kinmount in both St. Louis and Koochiching counties, Minnesota, there is a sandy ridge of glacial origin. The sand ranges from a few inches to sixty feet in depth. Below this sand is a granite-porphry ledge. Both the ledge and the sand carry gold. Repeated assays show that small seams in the granite-porphry ledge carry $10.80 or more per ton, and that the sand carries good values in gold.

The gold in the sand has most likely been leached out of the country rock beneath it and likely, also, been carried, for the most part, from some ledge in Canada, say Mine Centre or the Lake of the Woods region, and deposited there with the sand by some glacial eschar-streams. Both of the regions above contain gold-bearing rocks.

Gold in this region was discovered in 1910. A party headed by a Mr. E. P. Moorehead, were drilling for iron ore in the region and each time the drill was drawn up it was noticed that the earthy matter was glittering with bright particles. A sample was sent to Doctor Drew of Minneapolis and he reported that the sample contained gold at a ratio of $9.20 per ton. A spring also contained sand that assayed high in gold.

As a result of the finding of gold here, the Durheim Mining Company was formed with Mr. E. P. Moorehead as president. This company purchased 601 acres of placer land in township 60 of range 22 in St. Louis county, Minnesota, and 120 acres in township 66 of range 22 in Koochiching county covering the gold district mentioned. Since getting hold of the land they have been active in more than a prospecting way.

Contributions of the Drug Laboratory of the University of Kansas in the Enforcement of the Food and Drugs Law.

G. N. Watson.

In looking over the various state and national government reports on the analytical work of the food and drug laboratories and on the enforcement of the laws relative to this branch of service, we cannot fail to be impressed with the enormous amount of work that has been done and results accomplished during a decade of the food and drugs administration. During the ten years succeeding the passing of the food and drugs act of 1906, the Federal government made 6,000 prosecutions, had 40,000 hearings of manufacturers and examined 750,000 shipments of domestic and imported food and drugs.

One consequence of the enactment of the food and drugs act was the encouragement of similar legislation in many of the states. Among the pioneers in that work was the state of Kansas.

The Kansas drug regulations were largely copied from the Federal Act relating to drugs.

Regulation 36 of the Kansas drug law, relating to medicinal preparations, reads as follows: (1) Any official medicinal preparation for which a test is provided in the United States Pharmacopœia shall conform in quality, purity and strength to tests laid down therein. (2) Any official medicinal preparation for which no test is provided in the United States Pharmacopœia and National Formulary, shall conform to the preparation of product made from the official ingredients and by the process of the official formula for that preparation.

Regulation 5 (*a*) relating to the standards for drugs reads thus: A drug bearing a name recognized in the United States Pharmacopœia or National Formulary, shall be required to conform in strength, quality and purity to the standards prescribed or indicated for a drug of the same name recognized in the United States Pharmacopœia or National Formulary, official at the time of sale or when dispensed; provided that in case of homeopathic or eclectic drugs the same shall be required to conform to their accepted standards.

Regulation 5 (*b*) relative to proprietary medicinal preparations reads as follows: Proprietary medicinal preparations and similar medicinal products are required to conform in composition to the freshly prepared nondeteriorated article, and to conform to the claims made for the preparation as to therapeutic properties, quality and strength.

It is the latter clause, known as the Sherley Amendment to Section 8 of the Federal Drugs Law, relating to false statements of curative properties of proprietary medicines, that has resulted in some of the most interesting and important court decisions in the enforcement of the Federal Drugs Act.

Although provided with the necessary regulations, Kansas has never enforced this part of her drugs law but seemingly has been content to leave such enforcement entirely with the Federal authorities.

Among the proprietary medicines condemned by the United States

Court, based on the Sherley Amendment, may be mentioned: Dr. Williams Pink Pills, Eckman's Alterative, Nuxcara, Oxidase Tablets, Dr. J. H. McLean's Liver and Kidney Balm, Cummings Blood Remedy, Urol, The Great Magic Condition Powders, Dr. W. H. Baker's Tuberculous Remedy, Payne's Sylax, Hite's Pain Remedy and Cough Syrup, White Pine Expectorant and White Pine Balsam, Dr. Bell's Pine Tar Honey, Clay's Sure Cure, Lung Germine and hundreds of others that might be mentioned.

The Kansas State Drug Laboratory has examined and reported to the State Board of Health, during the past decade, 6,000 drugs, official medicinal and proprietary preparations, oils, coffee and spices. It has done coöperative work for the American Association of Agricultural Chemists on opium preparations, pepsin, coffee, spices and insecticides. It has done research work on various tests and quantitative methods. It has been called upon by residents of the state, and to some extent other states, for assistance on chemical, pharmaceutical and toxicological problems. To illustrate, the Laboratory has on hand for investigation, besides eight official samples, one sample of a so-called raticide that a citizen of the state suspects not to be as claimed by the manufacturer; a prescription to examine for harmful drugs; a sample of crude petroleum for general analysis and a sample of candy for presence of poison.

The effectiveness of the food and drugs law administration is evident from the fact that many abuses occurring in the food and drugs industries during the first few years of its existence have ceased. This has been noticeable in both Federal and state inspection work. A decade ago the drug stores of the state of Kansas, as shown by the specimens of drugs sent in to the drug laboratory for analysis, were in a rather deplorable condition. To-day our drug stores rank among the best. While misbranding and adulteration probably will never wholly cease (carelessness and dishonesty will always be with us), the never ceasing vigilance of government inspection will prevent drifting back to former conditions.

A Plague of Cholera Infantum at Nett Lake, Minnesota, in the Fall of 1913.

Albert B. Reagan.

Nett Lake, Minnesota, a shallow body of water, is a wild rice field in summer. In the early summer of 1913 it was at its normal level, and the rice rose above the water like a great oat field, and waved to and fro in the breeze till it had bloomed and begun to mature. Then there were exceeding heavy rains and the lake filled till the rice was entirely submerged and staid so several days. The water in the lake then returned to its normal level. Then as soon as the rice was matured the Indians returned from their picking berries in the surrounding neighborhoods and went to gathering rice. In this they rowed through the rice fields and pounded the rice off of the stalks into their canoes with clubs by a beating process as they rowed about here and there. When the canoe

was filled with the rice, which looks very much like bearded barley, they rowed to the shore and the rice was scorched in large caldron kettles which were placed over a hot fire as the rice was continually stirred with a paddle to keep it from burning. This scorching was done to get the husk off of the kernel. When scorched enough, the product was dumped into a sunken, cemented, tub-shaped place in the yard and tramped by a barefooted Indian to further remove the husks from the grain; the Indian washed his feet after the tramping was completed. The grain was then winnowed, after which it was washed. As soon as the first canoe loads were cleaned the rice was cooked, much as we cook oatmeal, and all sat down to a feast. The next day many were sick with a dysentery, and within a week 23 of the children under two years of age had died of cholera infantum. After the gathering of the first rice there came a heavy dashing rain, after which there were no more deaths of the fatal disease.

We had no government doctor at that time, the position being vacant on account of resignation. Consequently, as Indian agent, I wired the Indian office at Washington for medical aid. I also wired to Virginia, Minn., for a local physician to come at once, also to the state board of health at St. Paul to send us what assistance they could. But the fates were against us. The weather turned stormy, and Pelican Lake, which lay between us and the railroad, became so rough that it could not be crossed till the disease had worn itself out. Then we had doctors galore. Besides the local doctors the government sent two of its ablest physicians, and two state doctors came from St. Paul. No one was sick when any of them arrived. They had no case to diagnose, but proceeded at once to lay the disease to Colon Bacillæ in the well water.

We had five wells in the village. I had the water of each of these wells analyzed by the state board of health and Colon Bacillæ were found in but one of these wells, and that was in a well that had never been used by any one. The water of the well we all used was potable in every sense of the word. Moreover, some of the Indians did not use water from any well, but from the lake direct, and the children of these died of the disease the same as of those who used the well water. I maintained at the time that the rice caused the disease and still do so. I believe that a mold or fungus growth of some kind formed on the rice as a result of its being submerged and that all the rice gathered before its being washed clean by the terrific rainstorm aforementioned, was poisonous to the human system, and produced death to the infants and weaklings of the race, the same as the mold on the grass of the plains killed the horses off, I believe, the same year. As all the conditions remained the same, except that the rice in the field was drenched and thoroughly washed by a furious storm and immediately following the storm the ravages of the disease ceased, it is my candid opinion that the cholera infantum was caused by the diseased rice, or the toxic principle caused by same, and not by any contamination of the water.

Some Nutritional Characteristics of Corn.

J. T. WILLARD, Kansas State Agricultural College.

Paper read before the Kansas Academy of Science, January 15, 1916.

The origin of Indian corn or maize is buried in the silence of milleniums of the unrecorded history of man and his environment. It has been a cultivated captive so long, and has changed so much under restraint and domestication, that its original wild form is now extinct or unrecognizable. The earliest explorers of the Western World found it under extensive cultivation on both continents, from the valley of the La Plata in the south to that of the St. Lawrence in the north. According to Indian legends it was the direct gift of the Great Spirit, and it is certain that it was part of the Red Man's endowment of his conquerors.

Maize seems to have been taken to Spain about 1500 A D. and to have spread rapidly from that country to others bordering the Mediterranean Sea in both Europe and Africa. It was introduced into West Africa by the Portuguese, and the East Indies are indebted for it to the same adventurous voyagers. It spread so rapidly from its several points of introduction that some have even believed that it was indigenous to the Old World. Careful investigation, however, has shown that it was unknown there previous to the discovery of America. Its wide cultivation within a century thereafter is testimony to its excellence. It was welcomed and appropriated by prince, peasant and savage. Its beauty of figure, foliage, silk and tassel would give it a place in an artist's garden even though it carried no appeal to the economist. Its five hundred-fold yield places it at the front as a food producer wherever it can be grown, and in number and variety of food products for man and beast it excels all other cereals. From the moment when it thrusts its ivory plumule from the darkness of earth to the brightness and warmth of the spring sun to that in which its buffeted and broken body yields itself reluctantly to the mother soil, it is the emblem of sturdy determination and endurance, and the embodiment of the beauty of Youth, the unstinted service and generosity of Maturity and the resignation of Age.

The nutritional characteristics of any food depend fundamentally upon its composition and the chemical constitution of its components. As estimation of all values depends upon comparison, and nothing can be measured except by its contrast with or resemblance to something else, data will be presented for some other foods to a certain extent at the same time that they are shown for corn.

The composition of a food substance if completely known would show the percentage of each chemical compound present, and complete information concerning these compounds would include their inner constitution, or the arrangement among themselves of the chemical elements of

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NOTE.—For many years it has been the practice of the Kansas Academy of Science, at its annual meeting, to devote one session principally to a lecture designed to be of general interest and to bring the work of the members of the Academy to the attention of the general public. The lecture at the meeting held January, 1916, was given by Prof. J. T. Willard, of the Kansas State Agricultural College, who, as professor of chemistry and chemist of the Agricultural Experiment Station, has had opportunity to give considerable study and experimentation to corn and its products. In order to give the lecture a wider circulation in the state the Academy voted to have it printed as a bulletin. The Academy plans to issue bulletins of a scientific character and of general public interest from time to time as means and material permit.

which the compounds consist. The physiological relations of these compounds must also be known for any adequate study of their relation to nutrition; that is, we must know how they are affected by the digestive agents, and what possibilities the absorbed products of digestion present to metabolism, the complex physical and chemical processes that accompany the activities of living things. It need scarcely be said that we are not in possession of such complete knowledge of even one food substance. The purpose of investigations in nutrition is to explore unknown or little known areas in this field, in the hope that something will be found that is of benefit to man in one way or another.

The simplest expression of the composition of a food substance includes the proximate principles water, ash, protein, carbohydrates, and fat. This is of much service in spite of its incompleteness and indefiniteness. Better statements embody more details cencerning the ash, protein, carbohydrates or fat. Nearly always in the case of cattle feeds the fiber of the carbohydrates is separately stated, and the remainder placed under the heading of nitrogen-free extract, which really includes several classes of substances. The protein of the conventional statement is also a complex mixture of compounds, varying greatly in value, and in the mixtures found in different foods differ greatly from each other. The ash is the residue left after burning a food as completely as possible at a low temperature and is entirely different from the substances present originally. It contains metals, phosphorus, sulphur, etc., which were to a considerable extent constituents of organic substances in the food. The relative amounts of these elements, as well as the total quantities, give an insight into the dietetic adaptability of a food. These data can be learned only by detailed analysis of the ash.

The fat of foods as ordinarily determined is also an impure extract containing substances that are not fats, and usually several different fats. This sketch may serve to give an idea of the extreme complexity of foods and of the total inadequacy of the usual simple statements of their composition.

One of the most noticeable nutritional features of corn is the fact that both the grain and the stalk possess definite value. This is also true of wheat, oats and barley, but in these cases the straw is of little value. With the sorghums, to which belong not only sweet sorghum, but kafir corn, milo maize, feterita, etc., there is also notable value in both the grain and the stalk.

The corn plant may be utilized in several fundamentally distinct ways which may be mentioned without detailed consideration. If the corn is planted chiefly for grain and is permitted to come to maturity and the grain is husked out, the remainder is properly designated as corn stover, although often called corn fodder. Technically corn fodder is a crop produced by thicker planting, from which the ears are not removed. Such a crop is also available for conversion into excellent silage. In addition to these standard means of utilizing the stalks of corn, to a certain extent corn stover is finely shredded and converted into a product which can be conveniently stored under cover and fed to stock at better advantage, in that it is consumed more completely, and handled more conveniently.

Table I.—Percentage Composition of some Important Roughages.

	Water.	Ash.	Protein.	Fiber.	Starch, sugar, etc.	Fat.
Corn stover	40.5	3.4	3.8	19.7	31.5	1.1
Corn fodder	42.2	2.7	4.5	14.3	34.7	1.6
Corn silage	73.6	2.1	2.7	7.8	12.9	0.9
Sorghum fodder	41.7	3.0	3.2	17.0	32.2	2.9
Sorghum silage	76.1	1.1	0.8	6.4	15.3	0.3
Kafir-corn fodder	52.1	2.4	2.5	21.0	20.1	1.8
Kafir-corn silage	67.2	2.9	2.1	11.2	15.2	1.4
Wheat straw	9.6	4.2	3.4	31.1	43.4	1.3
Prairie hay	9.2	7.8	6.2	34.1	39.9	2.8
Millet hay	14.0	7.9	10.6	28.7	37.1	1.7
Timothy hay	13.2	4.4	5.9	29.0	45.0	2.5
Clover hay	15.3	6.2	12.3	24.8	38.1	3.3
Alfalfa hay	8.1	8.8	14.6	28.9	37.4	2.1

Table I shows the composition of several important rough feeds, in which those from corn are brought into comparison with those from other plants. Differences in the moisture content make direct comparison difficult. As a practical question much depends upon the care with which the several fodders and hays are harvested and preserved. Corn fodder and stover are especially subject to damage by wind and water, and while when in prime condition are valuable feeds, are likely to be rather inferior. There are no great differences between corresponding products from corn, sorghum and kafir corn. Reduced to the same moisture content, first-class corn fodder compares not unfavorably with prairie hay and timothy, but is distinctly inferior to clover hay and alfalfa hay.

Table II.—Percentage Composition of some Cereals and Products.

	Water.	Ash.	Protein.	Fiber.	Starch, sugar, etc.	Fat.
Corn, dent	10.6	1.5	10.3	2.2	70.4	5.0
Flint	11.3	1.4	10.5	1.7	70.1	5.0
Sweet	8.8	1.9	11.6	2.8	66.8	8.1
Pop	10.7	1.5	11.2	1.8	69.6	5.2
Green corn	75.4	0.7	3.1	0.5	19.2	1.1
Corn meal, bolted	12.5	1.0	9.2	1.0	74.4	1.9
Corn bran	9.4	1.2	11.2	11.9	60.1	6.2
Hominy	11.8	0.3	8.3	0.9	78.1	0.6
Wheat	10.5	1.8	11.9	1.8	71.9	2.1
Wheat flour	12.4	0.4	12.0	.....	74.0	1.2
Wheat bran	11.9	5.8	15.4	9.0	53.9	4.0
Rice, unpolished	11.9	1.2	8.0	0.9	76.0	2.0
Rice, polished	12.4	0.4	7.4	0.2	79.2	0.4
Rice polishings	10.8	4.8	11.9	3.3	62.3	7.2
Kafir corn	9.9	1.6	11.2	2.7	71.5	3.1
Oats	10.4	3.2	11.4	10.8	59.4	4.8
Rye	8.7	2.1	11.3	1.5	74.5	1.9
Barley	10.8	2.5	12.0	4.2	68.7	1.8
Millet seed	12.1	2.8	10.9	8.1	62.6	3.5

Table II gives the composition of different kinds of corn and some products, and for comparison that of several other cereals and products. These are the principal grains of the world. The relative rank of these is of some interest. There can be little doubt that rice is produced in greater quantity than any other, though statistics are not as available from the heavy rice-producing countries as they are from those which produce most of the wheat, corn, barley and oats. Taking the average

production for the years 1904 to 1913* inclusive, wheat has yielded 3,487,008,100 bushels, while the figures for corn for the same period are 3,662,229,400 bushels. The greatest yield of wheat in any one year was obtained in 1913, and was 4,128,711,000 bushels. The greatest yield of corn was in 1912, when it reached 4,371,888,000 bushels. It will be noted that in the average and in the maximum corn outranks wheat if the yield be stated in bushels. However, since wheat weighs sixty pounds to the bushel, while corn weighs only fifty-six, the weights for wheat are somewhat larger. The yield of oats is also about the same in bushels but much less in weight, while rye and barley each furnish about one-half as much. The fact that of the enormous total production of corn three-fourths is harvested in this country is ample basis for the saying, "Corn is king." Corn is easily the leading cereal of this country, and no other country possesses so large an area of soil adapted to corn culture. Argentine is next to us in production, but follows at a long distance. Hungary, Roumania and Italy are third, fourth and fifth in rank. The study of the nutritional value of corn is a problem commensurate in its importance with the magnitude of the world yield.

If the composition of corn be compared with that of other cereals, we may note that it is richer in fat than is wheat, and is somewhat lower in protein and carbohydrates. Comparing bolted corn meal with wheat flour it is seen that the superiority as to fat possessed by corn is not conferred upon corn meal. This is because the germs are largely removed by the bolting, and these carry more than three-fourths of the total fat of the grain. Corn meal furnishes twice as much ash as does wheat flour, and a somewhat greater quantity of carbohydrates. When we compare corn or corn meal with the polished rice of commerce, we see that in respect to all constituents except carbohydrates, corn is superior. Kafir corn, which fairly represents the sorghums, is also of special interest in this state, and is seen to be strikingly similar to corn in composition, but is poorer in fat. On the whole it may be noted that the seeds of all of these related plants have a strong general resemblance in composition.

The composition and physical character of the grain of different varieties of corn vary greatly. Sweet corn is one of the most delicious of vegetables when cooked in a green state, and its attractiveness is not altogether destroyed by canning or drying. The canning of sweet corn constitutes an extensive industry in this country, and the product adds much to the diversity of the bill of fare throughout the year. Dried sweet corn has a more delicate flavor, though of harder texture. Popcorn either with or without additions is a dainty of no mean order. However important these varieties of corn might otherwise seem, they are depressed into insignificance when brought into contrast with their coarser but more luxuriant brother, common field corn.

In utilizing the corn grain there is opportunity for still greater diversity of products than is the case with the stalks. The corn kernel consists of three well-defined parts, namely, the thin wall or bran surrounding the remainder of the kernel; the germ or embryo; and the endosperm, which constitutes by far the greater part by weight. The

* Year Book U. S. Dept. of Agr., 1914.

endosperm often shows distinct parts, one of which is of a clear horny texture, while the other is white and starchy in appearance. The physical characteristics, and to a considerable extent the chemical characteristics, of the corn kernel vary with differences in the relative amounts of the horny and the starchy portions of the endosperm. Other parts of the kernel which may be considered separately are the tip, by which it is attached to the cob, and the starch which is associated with the tip. Table III shows the percentage composition of corn and the distribution of its constituents among the several parts. The figures are reduced to a water-free basis and are given by Burtt-Davy,* who put them in this form from the results published by Hopkins.†

Table III.—Percentage Composition of Corn and Distribution of the Constituents Among the Parts. Dry Basis.

	Ash.	Protein.	Carbo-hydrates.	Fat.
Corn kernel	1.52	11.28	82.49	4.67
Tip cap	.02	.10	1.28	.02
Hull	.05	.24	5.48	.05
Horny gluten	.16	2.46	7.96	.55
Horny starch	.09	4.25	38.61	.09
Crown starch	.05	1.36	15.92	.05
Tip starch	.04	.70	9.36	.06
Embryo	1.11	2.17	3.88	3.85

Table IV.—Percentage Composition of Feeds Obtained From Corn Grain.

	Water.	Ash.	Protein.	Fiber.	Starch, sugar, etc.	Fat.
Corn meal, feed	15.0	1.4	9.2	1.9	68.7	3.8
Corn germ	10.7	4.o	9.8	4.1	64.0	7.4
Corn germ meal	8.6	2.4	21.7	8.8	47.3	11.2
Corn bran	9.4	1.2	11.2	11.9	60.1	6.2
Gluten feed	9.2	2.0	25.0	6.8	53.5	3.5
Gluten meal	9.6	0.7	29.4	1.6	52.4	6.3
Hominy feed	9.6	2.7	10.5	4.9	64.3	8.0

Study of Table III gives one an excellent idea of the characteristics of the different parts of the corn kernel and shows the basis for various chemical food products. The richness of the embryo in ash and fat is quite marked. In the manufacture of corn starch the embryo is separated, and with it the ash and fat are carried to a large extent. The embryo is also rich in protein. It may also be seen that the horny gluten carries much less carbohydrates in proportion than does the horny starch, while it is materially richer in ash. The figures are precentages based on the whole grain.

There are numerous food substances which consist of one or more parts of the corn grain that have been separated by mechanical processes. Corn meal is made by removal of the hulls and most of the germs, and finer grinding. Samp, hominy and grits are products in which the body of the corn kernel is much coarser than is corn meal, but from which

*Maize: Its History, Cultivation, Handling and Uses.

† Bull. 55, Ill. Agl. Expt. Station, The Chemistry of the Corn Kernel.

the hulls and germs are also absent. There are numerous breakfast foods consisting wholly or partly of some corn product. Corn flour is a fine starchy product obtained from corn and which may to a certain extent be mixed with wheat flour without unduly impairing the gluten-producing power of the wheat flour upon which its use in making yeast bread depends.

The proteins of corn do not, as do those of wheat, possess the power to form an adhesive glutinous mass when mixed with water, and hence cannot be leavened by yeast, or by baking powders to any great extent. The food use of corn and its products is thus restricted in some degree, but this very lack gives them a greater usefulness in certain other directions, such as in griddle cakes, puddings and mush.

Twenty million bushels of corn are used annually in the United States in the manufacture of alcohol and alcoholic beverages, and in this connection large quantities of by-products are obtained which are used in feeding cattle, milk cows and swine. Three million bushels of corn, rye and barley were used by a single Peoria firm in one year in the manufacture of denatured alcohol.

The manufacture of starch from corn is one of our great industries. This is used in part as such for food, and for stiffening goods, and largely for the manufacture of a number of substances produced by the glucose factories. Starch has a highly complex molecular structure, and in the presence of water, and under the stimulus of enzymes, acids or other agents it may undergo changes in which water enters into combination, and an extensive series of products is formed. The chemistry of these cannot be entered into at this time in any detail. Suffice to say that the articles of commerce are for the most part mixtures containing several of these alteration products of starch, the relative quantities of which differ in the different commercial substances. These alteration products are soluble starch, dextrines, maltose, and dextrose or grape sugar. The nature of the commercial product obtained depends on the degree of completeness to which the chemical change is carried, grape sugar being the final product, the dextrines and maltose marking stages in the transformation. After the process has gotten well under way all of the substances named are present, but as the change proceeds the dextrines diminish in quantity while grape sugar increases. By continuing the action long enough the total product finally consists practically of grape sugar only.

Another name for grape sugar is glucose, but in commerce the name glucose is applied to intermediate products that consist largely of dextrines, and are produced in the form of sirups from which grape sugar does not crystallize out. Commercially the final product is called grape sugar, and this is obtained as a solid substance. If this grape sugar be heated gently it is changed to caramel, which has a brown color and a characteristic flavor.

The personal experiences of nearly all of us are such that a mere naming of starch and these alteration products is enough to give a strong impression of the importance of corn as a source of accessory as well as staple food substances. Glucose sirup or corn sirup is extensively consumed, usually mixed with other sirups which give it characteristic

flavors. Karo and Mary Jane are examples of such products. Glucose, grape sugar and caramel are all extensively used in confectionery, and glucose is a constituent of many commercial jellies, preserves, etc., being used to give body, as it is itself deficient in sweetness or other flavor.

When starch is taken into the alimentary tract the digestive enzymes cause it to pass through the same series of chemical transformations that has been described as the result of the glucose manufacturer's art. It is, therefore, obvious that the artificial products are perfectly wholesome. As they come into competition with similar substances in which the sweet taste or sirupy consistence is due to cane sugar, or beet sugar, which are more expensive, it will be seen that food economy is furthered by the use of these glucose products, but that fair trade requires that they be sold for what they are, with no attempt to dispose of them as cane or beet sugar products.

There are several commercial feeds derived from corn, the composition of which is shown in Table IV. The simplest is corn chop, which is coarsely ground corn, and would, of course, have the same composition as does corn. In the production of starch, which is to a large extent manufactured for immediate conversion into glucose, the corn is steeped for some time to soften it, and is then ground in such a way as not to break up the germs and is separated, by means of running water and suitable machinery, into hulls, germs, starch, and protein substances in an impure state. The corn germs are usually separately handled and are ground and pressed to remove the oil, which is an important article of commerce. The residue is sold as corn germ cake, or ground and sold as germ oil meal. The protein substances, if separated and dried, constitute gluten meal, one of the richest of feeds in respect to protein and fat. It is not largely used as such, but is ground together with the hulls or corn bran, and the product is sold under the name of gluten feed, now the largest by-product of the glucose factories.

In the manufacture of hominy and grits the hulls together with some of the starchy substances of the corn grain are combined into a concentrated product known as hominy feed. Corn bran is seldom sold as a separate feed.

Table V.—Mineral Elements of Cereal Products. Percentages in the Dry Substances. Forbes et al.

	Total	Potassium	Sodium	Calcium	Magnesium	Sulphur	Chlorine	Total phosphorus	Inorganic phosphorus	Organic phosphorus
Corn	1.113	.396	.030	.014	.126	.171	.073	.303	.028	.275
Corn meal, bolted	.898	.192	.113	.015	.122	.122	.070	.264	.019	.245
Corn brand	.860	.410	.000	.030	.088	.124	.052	.156	.031	.125
Pearl hominy	.543	.153	.000	.005	.036	.186	.052	.111	.019	.092
Wheat	1.567	.590	.035	.056	.142	.224	.095	.425	.038	.387
Wheat flour	.577	.058	.124	.022	.019	.168	.081	.102	.017	.085
Wheat bran	4.946	1.464	.223	.139	.590	.297	1.000	1.233	.034	1.199
Rice, polished	.367	.040	.032	.009	.028	.114	.040	.104	.003	.101
Rice polishings	4.198	1.279	.124	.030	.741	.189	.151	1.684	.028	1.656
Kafir corn	1.083	.288	.066	.013	.142	.186	.117	.271	.012	.259
Oats	1.611	.460	.184	.112	.130	.214	.077	.434	.059	.375

Table V exhibits the elementary composition of the ash of several cereals and their products as determined by E. B. Forbes and his associates. The figures given under "total" are not comparable with those under "ash" in Table II, as the latter include oxygen that is combined with the other elements. Time does not permit much detailed comparison of the data shown in Table V, but attention may be drawn to a few points. Corn carries only about three-fourths as much total mineral elements or total phosphorus as does wheat or oats, while slightly exceeding kafir corn in these constituents. In calcium it is equal to kafir corn, but wheat has four times as much, and oats eight times as much. In the percentage of magnesium these four grains are almost identical. If now we consider the ratio of calcium to magnesium we find it to be as follows: In kafir corn, 1:11; corn, 1:9; wheat, 1:2.5; oats, 1:1.2. As in the human body the ratio of calcium to magnesium is 1:0.025 or 40:1, and this probably holds approximately for other animals, it will be seen that not only does corn exhibit a very low content of calcium, but that the ratio of calcium to magnesium is far lower than with these other grains, and that all of them provide calcium in much smaller quantities than they do magnesium when compared with the storage needs of a growing animal. Milk contains about eight times as much calcium as magnesium, nearly the reverse of the ratio found in corn.

While corn and its products are very extensively used as human food, corn meal being the cheapest of all food articles, the greatest use of corn is for the feeding of animals. When swine are fed, the cheapest grain is thus transformed into meat by the species that makes the most rapid growth of all domestic animals, and is therefore by the conjunction of these two factors the most economical source of meat that we have, or are likely to have.

Much might be said, if time permitted, on investigations with animals touching the nutritional characteristics of corn and its products. I wish to bring before you part of the results obtained in a series conducted jointly by President Waters and members of the Experiment Station force in the departments of Animal Husbandry and of Chemistry in the Kansas State Agricultural College.

It is a matter of common experience with practical farmers that corn does not seem to be a perfect grain food. Though used extensively with horses, cattle, swine and poultry, it is most satisfactory when accompanied by significant quantities of other feeds. Scientific men have sought to account for this by directing attention to the low ash content of corn, of which mention has been made. Going somewhat deeper, the unbalanced character of corn ash has been noted. In milk, calcium and magnesium are present in the ratio of about 7.6:1, in the animal body the ratio is about 40:1, while in corn grain it is only 0.11:1. Milk may be taken as Nature's guide to the proper relation of the several metals and other food constituents in food for a growing animal, and, tested by that criterion, corn has only about one-seventieth of the calcium that would be necessary to balance the magnesium present. If total solids be considered, it is seen that milk solids contain .770 per cent of calcium and .103 per cent of magnesium, while corn solids contain .014 per cent of

calcium and .126 per cent of magnesium. Compared with milk, corn has more than sufficient magnesium, but should have 55 times as much calcium as it has.

It has been found that in biological processes there is a certain antagonism between calcium and magnesium; that normal functioning requires a proper balance between them, and that presentation of excess of magnesium causes loss of calcium. With these facts in view it may be reasonably suspected that at least a part of the unfavorable results with corn are due to deficient and unbalanced ash.

Another possible explanation of the defective nutritional power of corn may be found in the constitution of its principal protein zein. An understanding of this requires some knowledge of the inner constitution of the proteins. These indispensable and highly complex compounds for many years baffled investigation of their chemical nature, and little real progress was made until about the beginning of this century. It is now known that to a large extent they consist of combinations of molecular nuclei derived from amino acids. These, with nuclei representing other classes of compounds, are linked together to form structures of only partially known and almost inconceivable intricacy. The proteins peculiar to different plant and animal tissues differ in their inner make-up, and to build up any one, in an animal tissue, for example, it is necessary that most of the specific nuclei of the body protein be present in the food protein. To only a limited extent, and in certain lines, is it possible for the tissue to synthesize its own nuclei.

There are about twenty amino acids which are represented in the proteins, and may be produced from proteins by suitable procedure, and in a somewhat loose way may be spoken of as present in the proteins. In digestion the amino acids are produced from the proteins, and are absorbed by the blood and by that channel distributed to all of the tissues of the body. The body organs synthesize their characteristic proteins from the amino acids and other substances, but the extent to which they are able to do this is limited by the amino acids that are present in the relatively minimal quantities. If a certain amino acid is required that is not present no protein can be produced; if it is present in but small amounts, relatively, others present in abundance can be used only to the extent that they are demanded to go with the one present in small amount, and so but little protein can be formed.

Mendel and Fine* have made digestion determinations upon the proteins of corn and have found that they are digested and metabolized somewhat less completely than those from meat. This does not show, however, that corn proteins are utilizable for the same purpose or with the same physiological economy as are meat proteins. The corn kernel† contains several different proteins, the principal ones being zein, which is present to the extent of about six per cent of the corn, and maize glutelin four and one-half per cent. Other proteins aggregate about four per cent. Together these proteins seem to contain nuclei of all of the animo acids, but zein, the most abundant one, is incomplete, glycin,

* Jour. Biol. Chem. X (1911-'12) 345.

† Osborne, Jour. Chem. Soc. XIX; 525. An. Rept. Conn. Agr. Expt. Sta., 1896, p. 391.

lysin and tryptophane being absent. The lack of glycin is believed to be a matter of no consequence, as it can be synthesized from other amino acids. With lysin and tryptophane, however, the case is different. If they are not represented in the proteins of a food, the organism is unable to make good the deficiency. Lysin and tryptophane are represented in all of the principal animal proteins, and, hence, must be supplied in the food proteins if true growth is to take place. It is possible, and indeed quite probable, that the quantities of these supplied by the proteins of corn are insufficient, and that the use of corn in nutrition is limited by these factors.

The experiments conducted at the Agricultural College touching deficiencies of corn have been upon young swine. These animals are well adapted to such tests because of the rapidity of their normal rate of growth, through which dietetic deficiencies would be accentuated, and results manifested more definitely and promptly than with a slow-growing animal. In the latter case a large proportion of the feed would be used in heat production, and elements, or certain molecular groupings presented in smaller quantities, might prove to be adequate because of the greater total quantity consumed for a pound of gain, the body conserving in its added tissue the molecular fragments most restricted in supply, and using the more abundant in the current need for muscle work and heat.

Another advantage of swine for such investigations is the fact that the young are produced in litters, thus making it possible to place in the different lots to be tested, animals of the same age and ancestry, and therefore more nearly alike than can be the case with cattle or horses. Experimental groups can thus be made up that are closely similar in essential respects.

For the last six years the Agricultural Experiment Station of the Kansas State Agricultural College has been conducting experiments in the nutrition of growing pigs with the object of ascertaining the nutritive deficiencies of corn and the means of correcting these. These experiments have been planned jointly by President Waters and the members of the departments of Animal Husbandry and Chemistry. It will not be possible to discuss the entire series, but the one just completed will, I think, be of special interest as determining almost positively some of the nutritional characteristics of corn. Some phases of the experiments of preceding years may also receive notice.

In all these experiments the pigs have been divided into lots of usually three each, the lots being made as nearly uniform as possible in respect to age, lineage and general characteristics of the individuals. Thirty-nine lots have been fed within the six years. This season ten lots were fed, which received the following rations:

(*Rations for ten lots of pigs fed, 1915.*)

Lot 30. Ground corn alone. Nutritive ratio 1:9.

Lot 31. Ground corn + ash. Nutritive ratio 1:9. Ash 2.5 per cent of corn.

Lot 32. Ground corn + defibrinated-blood protein nearly free from ash. Nutritive ratio 1:4.

Lot 33. Ground corn + defibrinated-blood protein nearly free from ash + ash. Nutritive ratio 1:4. Ash 4 per cent of ration.

Lot 34. Ground corn + starch + buttermilk casein + ash. Nutritive ration 1:9. Ash 2.5 per cent of ration.

Lot 35. Ground corn + buttermilk casein + ash. Nutritive ratio 1:3. Ash 2.5 per cent of ration.

Lot 36. Ground corn + buttermilk casein +ash. Nutritive ratio 1:6. Ash 2.5 per cent of ration.

Lot 37. Ground corn + buttermilk casein + ash. Nutritive ratio widened from month to month 1:3-4-5-6-7-8. Ash 2.5 per cent of ration.

Lot 38. Ground corn + egg-white protein nearly free from ash. Nutritive ratio 1:4.

Lot 39. Ground corn + egg-white protein nearly free from ash + ash. Nutritive ratio 1:4.

The ash used consisted of calcium carbonate 92 parts, calcium lactate 8 parts, tertiary calcium phosphate 10 parts, secondary potassium phosphate 37 parts, sodium chloride 20 parts, sodium citrate 15 parts, and ferric citrate 2 parts. Total 184.

Distilled water was used instead of ordinary water.

The purpose of the different lots may be briefly noted. Lot 30 was the fundamental one, the pigs being given ground corn and distilled water only. With this, lots 31, 32, 38, 33 and 39 are to be especially compared.

Lot 31 received the same as lot 30, and in addition an artificial ash consisting of a mixture of ash salts based on one used successfully by Osborne and Mendel,* and which was very similar to Roehmann's successful mixture. The change which we made was to omit magnesium citrate, on the supposition that corn is adequately supplied with magnesium, and to supply a much larger amount of calcium in the form of calcium carbonate.

Lot 32 differed from lot 30 in that in addition to corn and distilled water it received the proteins of defibrinated blood that had been treated especially for the removal of salts. Lot 38 was similar to 32 except that the proteins added were those of egg white freed form ash as nearly as practicable.

The pigs of lots 33 and 39 were given both ash and purified protein in addition to the corn and distilled water.

By comparison of the results of these six lots one learns the results of feeding corn alone, and the effect of supplementing it by ash or protein or both, and may observe the relative effect of proteins from two sources. These proteins are complete in that they furnish all of the required amino acid complexes.

The nutritive ratio of corn is wider than is believed to be best for the nutrition of young growing swine, that is, the carbohydrates are present in too large an amount relatively to the protein, the nutritive ratio being about 1:9. The purpose of lot 34 was to ascertain how pigs would grow on a ration of the same nutritive ratio as corn, 1:9, but which contained casein, a protein that previous experiment had shown to supplement corn perfectly. The casein added was balanced by corn starch. Ash was also supplied this lot.

* Publication No. 156 Carnegie Institution of Washington, Part I p. 32

Table showing initial and final weights, in pounds, of pigs in nutrition experiment No. 6, concerning the deficiencies of corn. K. S. A. C., July 3 to December 30, 1915, 180 days.

Lot No.	Individual No.	Initial weights.		Final weights.		Average monthly gain.	Lot No.	Individual No.	Initial weights.		Final weights.		Average monthly gain.
		Individuals.	The lot...	Individuals.	The lot...				Individuals.	The lot...	Individuals.	The lot...	
	10	28		31				10	28		31		
30	1000	31	76	61	113	2.1	30	1000	31	76	61	113	2.1
	101	17		21				101	17		21		
	110	28		32				1110	23		164		
31	1001	29	78	36	98	1.1	34	1100	31	72	184	494	23.4
	102	21		30				121	18		146		
	1101	29		108				2002	20		208		
32	1010	25	75	79	248	9 6	35	2	19	59	234	602	30.2
	112	21		61				111	20		160		
	2001	30		192				2010	23		229		
33	11	18	71	161	525	25.2	36	12	21	61	171	600	29 9
	201	23		172				1011	17		200		
	1003	26		59				2000	18		207		
38*	.....	.....	55	.....	139	8.4	37	1	22	61	222	609	30 4
	3110	29		80				1012	21		180		
	1002	24		183									
39*	.....	.....	57	.....	385	32.8							
	2110	33		202									

*August 2 to December 30, 1915, 150 days.

Lots 35, 36 and 37 were introduced for the purpose of still further guiding our conclusions by knowledge concerning the possible influence of nutritive ratio on the results that might be obtained. Corn, buttermilk casein, and ash were used in each case. In lot 35 the nutritive ratio of 1:3 was narrow, that is, it was rich in protein, that of lot 36 was 1:6, intermediate between lots 34 and 35, while that of lot 37 was narrow at the beginning of the trial and widened month by month.

In lots 34, 35, 36 and 37 the same food substances were used, but in different relative amounts. The substances were known to be adequate for nutrition, but the most suitable relation among them might well be an important question for investigation, and the lots furnished a valuable background for judgment concerning the other lots.

Table VI summarizes some of the more interesting points concerning the growth of these pigs. As the experiment has just been concluded the chemical results are not at hand as yet. The gains made by the several lots show unmistakably their general nutritional condition. The pigs were about two and one-half months old when they were put on experiment, and were of nearly the same age. Each pig was fed what it would eat up clean. Of course those that made the highest gains did so by consuming the most feed.

The corn-fed lot gained very little, though the largest pig greatly surpassed the others in its own lot, and also those in the corn-and-ash lot, No. 31. While it gained thirty pounds, the average total gain of the other five referred to was only five and four-tenths pounds. It is perfectly evident that the addition of ash only to the corn did not completely supplement it.

Comparison of lot 30 with lots 32 and 38 shows that the blood and the egg protein when not accompanied by ash did not enable normal growth to be made, although the results were better than those shown by ash alone, the average gain per day of each of the six pigs being about three-tenths of a pound.

Consideration of lot 33 shows that here, where both ash and blood protein were added to corn, a very good growth was obtained, it being about five-sixths of a pound per day per pig. In lot 39, in which egg-white proteins were added with ash, each of the pigs gained over a pound a day for the 150 days that they were in the experiment, and made the most rapid growth of any lot in the test.

Valuable information is contributed by lots 34, 35, 36 and 37, all of which received corn, and commercial buttermilk casein, and in which lot 34 was also fed corn starch in order to reduce the nutritive ratio to that of corn. Lot 34 was notably inferior to the others, and shows that a nutritive ratio as wide as that of corn is not suitable for young growing pigs, even though it contains a supply of so admirably adapted a protein as is milk casein. The other three lots are not very different in outcome, though up to the last three weeks lot 37 was distinctly in the lead. In this lot the nutritive ratio was narrow at first, when the young pigs were actively forming protein in their bones, glands, muscles and connective tissue, and as these fundamental cellular structures came to be supplied, and growth consisted more and more in the storage of fat, the relatively reduced supply of protein was entirely adequate. The excellent showing made by these pigs throughout the trial confirmed the scientific judgment which anticipated the results obtained.

On the whole we may conclude from this experiment: (1) That for young pigs, corn is deficient in ash; (2) that it is also deficient in protein; (3) that the protein of corn is defective in character. That additional ash is needed is established by the facts that when pure proteins of complete amino-acid constitution, derived from blood and from eggs, are fed with corn, they are ineffective unless accompanied by additional ash. The deficiency of total protein is shown by the superior results obtained in lots 35, 36 and 37 over those shown by lot 34 with its lower supply of the same protein. The fundamentally defective character of the corn proteins is proven by the greatly superior results shown by lot 34 over lot 30. In these two lots the relative amount of protein in the ration was the same, but the presence of the complete protein, casein, determined a very good growth in lot 34, while in lot 30 two of the animals barely lived through the experiment, and the others made but a small growth.

A very interesting experiment was conducted at the Wisconsin Agricultural Experiment Station on sixteen grade Shorthorn heifer calves, divided into four lots of four each, as nearly equal in weight as possible.* The plan of the experiment included subjecting these animals to all of the strain naturally coming to the species, including reproduction and lactation. It was therefore continued through four years at least, beginning May 31, 1907. Through this length of time one lot was fed

* Research Bull. No. 17, Wis. Agr'l Expt. Sta.

wholly upon the products of the corn plant, another upon products of wheat plant, a third upon products of the oat plant, and the fourth upon a mixture of equal quantities of products from the three plants, corn, wheat and oats. The corn ration consisted of corn stover, corn meal and gluten feed; the wheat ration of wheat straw, wheat meal and wheat gluten; the oats ration of oat straw and rolled oats. The feeds were balanced to a nutritive ratio of 1.8, that is, of the total energy available to the animals about one-ninth, or about eleven per cent, was from protein.

The results of the trial cannot be given in anything but outline at this time. It was found that there was nothing in the rates of growth or the total gains in live weight to indicate that one ration was very much superior to another. At the end of two years, however, there was a marked difference in the appearance of the corn lot and the wheat lot, the other two being intermediate. The corn-fed animals looked smooth of coat, fuller through the barrel and were in a better state of nutrition than any of the others. The wheat-fed animals had rough coats, were gaunt and thin in appearance, and small of girth and barrel, and to the eye of the practical man in a lower state of nutrition.

The greatest differences in the lots were shown in the performance of the reproductive function. Within the last two years of the experiment the four cows of the corn-fed lot produced eight strong and vigorous calves, all of which lived. With the wheat-fed lot, six weak calves were produced. One was born dead, the others died within a few hours. The second year one of the cows died of anthrax and another by accident, and on this account there were but six calves in the lot. The oats-fed cows produced one dead calf, one so weak that it died on the third day, and six that, though of varying degrees of weakness at birth, were able to live by the aid of special nursing in some cases. The cows receiving the mixture ration gave birth to two dead calves, one that lived only six hours, and three that lived, although weak or only fairly strong. One of these cows was not with calf the second year, and one aborted the first year by reason of an accident.

This highly suggestive experiment, only the main features of which have been touched at all, shows that the entire corn plant was markedly superior to the oat plant, wheat plant, or a mixture of all three of these, in the nutrition of heifers when subjected to the strain of maternity and lactation. This does not prove that similar relations would exist with other species of animals. The experimenters, Messrs. Hart, McCollum and others, were not able to determine the cause of the superior results given by the corn ration.

I cannot conclude this incomplete discussion of the nutritional characteristics of corn without some reference to pellagra. This disease, which is coming increasingly into prominence, has been observed to affect many whose diet consists almost entirely of polenta, a sort of corn-meal mush, and it has been suspected that corn is the cause of the disease. By some it is thought to be the result of consuming unsound rather than unaltered corn products. While the problem cannot be regarded as fully solved yet, and corn completely acquitted from responsibility, there is at present no proof that corn in any form causes the disease.

In connection with the subject of vitamines, or food accessories essential to growth which are not included among the ordinary food principles, it is interesting to note that corn carries both an oil-soluble and a water-soluble accessory. Professor Hughes at the Kansas State Agricultural College has shown that pigeons which had been brought to the last stages of polyneuritis by feeding polished rice or kafir corn may be entirely relieved from the symptoms by administering twenty grains of corn.

The nutritional characteristics of corn have been but imperfectly treated in the foregoing, but it is hoped that enough has been given to show the great variety manifested by these characteristics and the practical importance of scientific interest in them.

American Highways.

J. A. G. Shirk, M. A.

Nothing is a better indication of the degree of civilization attained by any nation than its roads. Many places in Europe and Asia we find yet to-day remains of the great chain of roads built by the Romans. Every block and stone in them is typical of the vigor and strength of the Roman civilization. All these roads led to Rome, so that she might send her armies out quickly to quell any uprising and also that the world's commerce might center in their capital city. In China we find the main roads as mere paths, and thus they have been for centuries, typical of a civilization that is without ambitions or ideals.

Roads are made because there is some imperative need for a means of getting from one place to another. The lower animals resemble man in this particular. Those animals lower down in the scale of life either live upon the food about them, or are carried about by the forces of nature or by larger animals. But as the needs increase, the paths they follow become longer and better defined and we find that there is established what might be termed a highway. In this continent, the best example of permanent animal trails were those made by the American buffalo which led to their feeding grounds, their watering places, and salt licks. The first real thoroughfares of America were probably those made by the big game animals, such as the buffalo. These plunging animals, keen of instinct, moving in vast hordes, broke great roads across the continent along the summits of the watersheds, beside which the Indian trails were mere traces. These roads were swept clear of debris in summer and of snow in winter, so that the early settlers found them of the greatest use in the settlement of the wooded country just west of the Alleghenies. These paths led to the passes through the mountains, and beside the small streams or springs which were good watering places. Along these buffalo trails followed the slow plodding oxen drawing the ponderous wagons of the settlers, and thus the trails were changed into roads, which by fortification and small improvements became the great arteries of travel and traffic between the coast colonies and the settlements and trading posts further west.

The Indians made many trails for purposes of war and peace. Each tribe generally had a hunting ground at some distance from its usual

place of abode. They made their chief habitations at the places where it was better to winter, or to repel the attacks of their enemies, and as the game would soon be almost wholly exterminated in that vicinity frequent excursions would be necessary to the localities where there was still an abundance of wild animals. When the tribes were at peace there was a hunting ground for each tribe, and trails were made to these regions. These trails were never more than mere paths, bordered by the forest, and often made impassable by storms felling trees across them. They were generally laid out so as to follow the high ground and missing the numerous bogs which impede travel yet to-day on many eastern roads, especially in the wet season. These trails were never improved by the Indians, who merely shifted the trail if some difficult barrier developed. The only vehicle used by him was two poles, with a few cross pieces, tied to a pony, and as the party always traveled single file, the path was very narrow. The trails were never blazed, this being an invention of the less instinctive white man. The war trails were often broader and in better condition because of their almost constant use by the larger parties of warriors. Many of these war trails became the wagon roads for the brave and courageous pioneers, chief among them being the "Connecticut Path," the "Iroquois Trail" and the "Virginia Warriors' Path." The trader also followed these Indian trails because they led him to the people with whom he wished to barter, and likewise the missionaries and explorers who gave us the first knowledge of the great fertile country separated from the coast settlement by the barriers of mountains.

Daniel Boone laid out the first road from Virginia to Kentucky for the Transylvania Trading Company, and Captain Cresap acting for the Ohio Company blazed the first trail from the Potomac to the Ohio. Both of these roads followed Indian trails and buffalo traces most of the way. Washington followed narrow Indian trails on his mission to Fort Necessity. Braddock followed the same rough path next year, making a great gorge of a road twelve feet wide still visible to the place of his defeat. This road is also known as the Virginia Road. Few roads ever cost so much, ever amounted to so little at first, and finally played such an important a part in the development of the continent. It was built by Major-General Braddock in 1755 during the French and Indian war. The Atlantic coast was settled largely by the English, who built towns and villages, and developed the resources of the country. The Mississippi valley was first discovered by the French who made lengthy voyages of exploration along the navigable streams. They made friends with the Indians and adopted many of the Indian habits and customs, but never actually occupied the territory as did the English on the coast. Forts were constructed at the mouths of rivers and at the principal portage paths. The French believed in the strength of natural barriers. In Europe, France was separated from both Spain and Italy by high mountain ranges, and she had not been taught by a Napoleon that such barriers while difficult to overcome are not unsurmountable. France lost her empire in the New World because she trusted too much in natural barriers and fortifications. At Louisbourg and Quebec the French com-

manders trusted in the strength of crags and precipices, and in the central empire they trusted in the Alleghenies. When Braddock first came to assume the offensive against the French he requested the governor of Pennsylvania to construct a road to the Ohio river, while he would lead his army over the road from Virginia, formerly used by Washington. The road was cut twelve feet wide to allow his wagons and artillery to pass through, and finally when he had all but won over his foe he was defeated by the cunning of his Indian antagonists. As soon as the news of Braddock's defeat was received by the men who were cutting the shorter road across Pennsylvania, they immediately fled back to the eastern settlements. This victory of the French and Indians aroused the colonists, who before had given very little support to Braddock. In fact we might say that the lack of coöperation on the part of colonists was largely responsible for the failure of Braddock's mission.

Three years later Brigadier-General Forbes was assigned to the unfinished task, and he led a more united army west over the road formerly started by Governor Morris of Pennsylvania. This road was completed to the present site of Pittsburg, and terminated in what is now Forbes avenue of that city. Forbes built several forts, conquered the French and Indians, and firmly established the English in the region of the Ohio river, but like Braddock, he gave his life for the effort. This road was much shorter than the Virginia road laid out by Braddock, and became the military road to Ohio and the Western Empire. Over it also was carried the trade between the east and the west. Pennsylvania improved this road just after the Revolutionary War, and it became the connecting link that bound the state together.

What General Forbes accomplished for the settlement of Ohio by the opening of the Pennsylvania road Boone did for Kentucky in the opening of the famous Wilderness road. Boone was probably the first white man to visit the fertile blue grass region of Kentucky, which was, even in the wild condition, a second "Garden of Eden," as he described it. But a veritable wilderness separated it from the country already settled, and the hardships endured by the early pioneers who sought to reach this favored location were almost unendurable. Finally Boone led a party which blazed a new trail leading from the Virginia road, and also fortified it at a few places. This road was the longest, blackest and hardest road of pioneer days, but it is the only one which has held the oldtime name. The reason the name has been retained is the fact that the road has also retained considerable of its ancient characteristics.

The roads which have been described thus far were never improved to any great extent. When first laid out they were merely paths cut through the forest leading from one fording place to another, and generally followed the high ground so as to miss the bogs. Most of them had two roadways, a wet and a dry one being laid out at many places. A wet road was one used during the wet season, and the dry road followed the lower ground which could be traversed only during dry weather. The term roadway is also quite misleading, since the only ones wide enough for wagons were those constructed for military purposes, as Braddock's Virginia road and Forbes' Pennsylvania road. The trails

first laid out were generally along more or less well-defined Indian trails, and the pack horse became the only possible method of conveying passengers or freight.

The first step in improving the roads was in widening of the trail so as to allow wagons to be used. The next was the corduroying of the worst wet places with logs laid across the road and long enough to sustain the vehicle. Before this was done each teamster tried to avoid the deep ruts produced by the wagon preceding his own, and then he might get into a worse place and mire down completely and even lose his oxen or horses and wagon. It is stated that at times five ox-teams were necessary to pull a load of one ton. Some of the local names of settlements or roads reveal the nature of the highway. One town in Indiana was named Mudholes, and the road from Pickaway Plains of Ohio to Detroit was known as the "Bull Skin Road" on account of the large number of dead oxen along the route.

The cost of transporting freight under these conditions may be imagined as very high, when a pack horse could only carry from 150 to 200 pounds. Even the wagon rates were almost prohibitive, the cost from Philadelphia to Pittsburg being from $5.00 to $10.00 per hundred pounds, according to the nature of the roads. This was a big reduction from the pack-horse rate, and consequently the pack-horse men very bitterly opposed the widening and improving of the trails. They destroyed vehicles, assaulted drivers and passengers, vindicating their acts by stating that the new method was destructive of trade and caused deterioration in the breed of horses and the physical strength and vitality of men. Their opposition was futile, and most of the pack-horse men probably went into the business of teaming or coaching. It is quite probable that some of these same men may later have taken part in the similar acts of the teamsters when the first railroads were constructed. At any rate we know that similar arguments were used to incite rioting. This has, however, been the usual attitude of any class of workmen when some new invention or industry made it possible for one man with skill to do the work of several.

The minor roads were usually mere trails leading to the main thoroughfares, and at first were wholly unimproved. At the same time that the states were "corduroying" or "macadamizing" the more prominent roads, the minor ones were being similarly improved by the privately owned turnpike companies. These companies were granted the privilege of constructing roads and charging tolls to reimburse them. Some of these turnpikes were lucrative investments, and consequently many such roads were constructed that never returned the original capital to the investors. Many were built, however, from exactly the same motive that later made the people vote bonds for the railroads, viz., the development of the community.

In 1800 President and Mrs. Adams tried to get from Baltimore to Washington, but such was the condition of the roads that they became lost in the Maryland woods. This shows the condition of the roads leading to our capital city at that date.

Probably the first roads that were placed in really fine condition were some of the private turnpikes. The Philadelphia and Lancaster Turnpike

Road Company started work on that road in 1792, and completed it in 1794, at a cost of $465,000. The road was started 100 feet wide, but it proved so expensive that it was reduced to almost one-half that width. This road was very straight, except when detours were absolutely necessary to reduce the grades. It is to-day paralleled by the Pennsylvania Railway almost the entire distance. Not only was it laid out well and constructed of generous width, but the construction was well done. The stones used were required to pass a two-inch ring, and were thoroughly compacted by allowing traffic over each layer before another was applied.

This road had no competition for twenty-one years, and then the horse cars and canals came. It was then left to deteriorate until the public refused to pay the tolls. Seventeen miles were abandoned in 1880, and taken up by the townships, which have placed these sections in fine condition. Ten miles, however, was retained until 1899 when it was sold to a traction company for $10 per share. These shares originally cost $300 per share, and out of the 1,200 shares first issued, 200 were kept as souvenirs or were lost.

The finest road of that period was the Cumberland Road, generally know as the National Road, because it was and is yet the only great road constructed by the national government. The hardships endured on the road by those who went to settle in Ohio and Kentucky prevented many others from attempting the trip, and this barrier of bad roads was not only hindering the further development of these states, but was also contributing to the general feeling of unrest which made the western settlers think that perhaps they should organize a separate government. Henry Clay, being a Kentuckian, became an earnest advocate of a national highway connecting the West with the East, which was Washington's cherished dream. The project received a great impetus when Albert Gallatin, secretary of the treasury in 1806, urged such works of internal improvement. The first appropriation of $30,000 was made March 29, 1806, and the last on June 17, 1844, a total of $6,824,919.23 being appropriated for this road. The original estimate of the road was $6,000 per mile, but actually cost $9,745 per mile from Cumberland, Maryland, to Uniontown, Pennsylvania, and $13,000 per mile from Uniontown to Wheeling, Virginia, now West Virginia. The excessive cost of the second portion was probably due partly to too liberal contracts. The road was started in 1811 and during the next thirty years was completed to Indiana and graded part of the way across Illinois. The portion built to Wheeling was completed in 1818, and at once became the most famous American highway. Over this sixty-foot rock road passed a constant stream of wagons, mostly bound for the plains of the fertile valleys of the Ohio and Mississippi rivers. The enthusiasm of the western settlers knew no bounds when it became known that the road was to be constructed, and from that time the East and West were tied together firmly. In fact, the effect upon the political life of the western territories was even greater than upon their commercial life, because long before the road actually reached them, a new and more rapid form of transportation was developed. When the railroads finally took almost all of the interstate commerce and travel, the road was abandoned without completing it, as first planned, to the Mississippi river.

From the engineering standpoint it was probably the best rock road constructed in America, there being three layers of stone used, good drainage, low grades, and excellent bridges. It was almost as straight as Peter the Great's famous road to St. Petersburg, which was laid out by the imperious monarch himself by the simple process of laying a ruler down on the map between the desired terminals. On the engineering staff we find the names of McKee, who fell at Beuna Vista, Williams, at Monterey, and Major-General Mansfield, at Antietam.

Much objection to the construction of the road was made on constitutional grounds, but it was finally constructed under the authority given to the government to regulate post roads and the mails. However, when the question of keeping the road in repairs came up it was thought best to turn it over to the states within whose borders it passed for the purpose of erecting toll gates and using the revenue obtained in this manner for keeping the road in repair. The position of toll gate keeper was quite a lucrative one, but Ohio alone received $1,139,795.30 from tolls from 1831 to 1877. This indicates the vast amount of travel over the road even when railroads and canals were being rapidly developed.

For at least three sessions of congress previous to the last appropriation for the National Road, various committees and individual members urged that the remaining portion of the highway be made a government railroad instead of a wagon road, but when each time the matter came to a vote, these amendments were struck out, and the original plan was pursued.

The principal rivals of macadamized roads were those known as plank roads. The first plank road in America was constructed in 1835-'36 at Toronto, Canada, and the first in the United States in 1837, near Syracuse, N. Y. This form of roadway proved very popular, there being 2,106 miles constructed in New York alone during the next fifteen years. Plank roads were made of 3″ x 8″ planks laid crosswise of the road, and fastened to stringers. Such roads cost about $2,000 per mile, or about one-fifth of the cost of the Cumberland Road. The tractor power was much less than on the rock roads, one team easly pulling as much as six tons on low grades. Sometimes these plank roads were constructed as a neighborhood enterprise, and were only second to a log rolling in popularity as a social event.

With the rapid rise of the railroads, there came a corresponding decline in road making. The Federal government ceased entirely to devote any attention to the subject, and the same was true of almost all of the states. The power to improve and repair the roads was left almost wholly to the townships or small road districts. The expense for this work was largely borne by a poll tax which might be worked out by each individual if he so chose. The road overseer was generally quite ignorant of the proper methods of road drainage, establishing of economical grades, and kindred subjects. Consequently we had for many years a system of roads only good in the dry seasons.

In the last twenty-five years there have been two important developments which have done a great deal for the improvement of our roads, and are destined to accomplish much more in the near future. The first

is the application of efficiency principles to the farm, and the second is the use of the automobile for recreation. Each will do its own part towards making our roads what they should be.

Both are being aided in every way by the manufacturers of road building material or machinery. The national government is now doing much to help the efficiency of the farm through the Department of Agriculture and its branch, the Office of Public Roads, and Rural Engineering.

Perhaps it might be well to give a few reliable estimates concerning how the question of the roads affects the profits of the farm. America has a marvelous railroad system reaching throughout the length and breadth of the land, and yet the average farm is located from eight to ten miles from the nearest station. Also, probably seventy-five per cent of the commerce of this country starts on the wagon roads, since we are essentially a producer of raw materials. We may conservatively estimate that at least $700,000,000 is expended annually in getting our produce to the railroad. This cost is exorbitant, and the great problem of the Office of Public Roads is how much of this can be saved by a good system of country roads. It is simply a matter of striking the proper balance between the saving effected by good roads and the expense incurred in improving and maintaining them. This has been worked out very carefully, and the justifiable expenditure in relation to the tonnage or number of vehicles passing over the road has been determined with sufficient accuracy. It will be seen at once that according to this principle, a system of public roads should, like a railroad system, consist of a limited number of well-constructed trunk lines with a larger number of feeders of more moderate cost. Any community which does not act on this principle is wasting money, for if all are constructed poorly the saving in hauling is not as large as it should be and also the expense of maintenance is greater, while if all are made of expensive construction the saving in hauling might not justify the large expenditure.

Poor roads mean, however, not only an economic waste in hauling but they hinder greatly the social and intellectual development of the rural community. Consolidated schools, community centers, and good country churches are only possible where the roads are good, especially in the winter season when the country people have the leisure time for social and intellectual advancement. It seems to have been demonstrated conclusively that where good roads permit of a proper social development the young people are more likely to remain in the country even after taking advanced school work in the higher institutions of learning.

The merchants are aiding the good-roads movement in every possible way, in some instances building a mile or more of good road to serve as an object lesson to the farmers and enlist their coöperation. The merchant realizes that good roads are a valuable asset to his business, and that town which has a network of well-constructed roadways converging to it will enjoy a much larger patronage from the country people and the residents of the smaller communities.

The problem of road building has in the past been almost wholly left to the small unit, as the township or road district, but during the past decade many states have passed laws making it possible to obtain state and

county aid. The New York law empowers the state to pay fifty per cent, the county thirty-five per cent, and the township fifteen per cent. In Ohio the state pays twenty-five per cent, the county fifty per cent, and the township twenty-five per cent, this last twenty-five per cent being divided into fifteen per cent by the township as a whole, and ten per cent by the owners of the abutting property.

In New Jersey the state pays one-third, the county one-third, and the owners of adjacent property one-third. Many other states have similar laws, but as yet Kansas given no state aid.

The Hodges law allows the township to pay twenty-five per cent and the property owners seventy-five per cent. The seventy-five per cent is generally levied on a zone not more than two miles on either side of the road. In the main it has been fairly satisfactory, but before we shall have an extensive system of roads we must institute the state-aid plan. The plan proposed by several prominent men is for the state to issue $25,000,000 of bonds to get the necessary funds for the improvement of the roads. Many believe that the next legislature will take the initial steps in getting this matter before the people of Kansas. This plan has produced more mileage of good roads in Ohio than any other state of the Union of approximately the same size.

But we are probably reading and hearing more to-day about the long transcontinental highways and the connecting roads between large cities, chief among those which have already been marked out being the Lincoln Highway from New York to San Francisco, and the "Old Trails Road" from Washington to San Francisco. This follows Braddock's road from Washington to Cumberland, Md.; the Cumberland or Old National Road from Cumberland to St. Louis; Boone's Lick Road from St. Louis to Old Franklin; the Santa Fe Trail from Old Franklin to Santa Fe, N. M., and the Grand Cañon route from Santa Fe to San Francisco. All of these are noted trails, but the last one is best known here. It did for the development of the great southwest what the Cumberland road had done from the central states.

These projects are being pushed vigorously by the automobile associations of the various states through which they pass, and also by local commercial interests who derive benefit from the amount of travel which the roads produce. Parts of these roads have been put into excellent condition, but the major portions are only marked, and much work needs to be done upon them before it will be possible to really "See America" as it has been possible to tour Europe before the outbreak of the present war. The great barrier of mud has prevented our eastern population from really coming into intimate contact with the western people. They come on the trains, stay at hotels which cater to their trade, and leave for their homes with little or no conception of the spirit which animates the West.

This condition must not continue, but the only solution is Federal aid. In the case of the Lincoln Highway, there are several states through which it passes where it is impossible to make the necessary improvements. Nevada has 425 miles of the highway and only 80,000 people. The same is true of Utah, and to a lesser extent of Nebraska. The high-

way is in almost perfect condition to Indiana, but from there on west it is mainly a dirt road, although much better kept than the neighboring roads. Last summer it is estimated that 5,000 men were busy at one time improving this highway, and when we remember that the concept of a transcontinental highway is less than three years old, we may be well pleased at the results already accomplished.

These extended highways will do more to thoroughly knit our citizens together in the firm bonds of a mutual understanding of each other's problems than any influence now discernible.

But, as stated before, such great enterprises cannot be successfully completed without Federal aid, and it appears now probable that the national government will in the near future reëmbark on the great problem of road building with which it has done almost nothing for over half a century. Then, when nation, states, counties, and local communities work together, we may construct such a network of roads as will make them the pride and boast of every American citizen.

A Study of Foods for Infants.

Leon A. Congdon, B. S.

When we come to consider the great number of proprietary foods for infants which are rapidly flooding the markets, we cannot help but pause and study the value of these proprietary products. The reason for such a flooding of the market with these proprietary foods is evident because, first, a great many mothers are unable to nurse their children, and, second, a great many will not nurse them because of a so-styled reason of their duty to society. The first reason should have the sympathy of everyone, but the second is no reason at all and should be discouraged.

This article will not deal especially on the infant-feeding question, but will be confined to a study of foods for infants, giving such facts as will tend to discourage the use of proprietary foods. When we stop to study the composition of the largest sellers among the proprietary foods for infants we are impressed with the fact that they are comparatively useless, and in some cases harmful to children under one year of age. In fact, a study of the available statistics in this country and abroad goes to show that high infant mortality is due either to the improper feeding of cow's milk to infants up to six or nine months of age, or, in all probability, is due to the feeding of artificially prepared patent baby foods which set up a disturbance of the child's delicate digestive organs. The late Walter Wyman, of the United States Public Health Service, said that it is recognized that gastro-intestinal disease is the largest factor determining infant mortality, a condition in great measure due to improper methods of feeding, and that this enormous loss of potential wealth is of grave concern to the state and worthy of most careful consideration.

Chart 1 shows the relation of the nutritive ratio to the physiological fuel value of the most common proprietary foods for infants found in this country. This chart also shows this relation in comparison with

cow's milk and human milk calculated on the same dry basis as the proprietary foods. In the physiological fuel value, the results are expressed in large calories per 100 grams of the sample. The factors used were fat 9, protein 4, and carbohydrates 4, these being the physiological fuel values of food constituents. The nutritive ratio is, according to Sherman's formula:

$$\frac{\text{Carbohydrates} + 2\tfrac{1}{4} \times (\text{fat})}{\text{proteins}}$$

In studying this chart one cannot help but realize that the only known substitute for human milk in this country is cow's milk, especially in its physiological fuel value. Dr. Joseph W. Schereschewsky, formerly of the United States Public Health Service, says that cow's milk is the only food supply, apart from mother's milk, that is available in this country, from a practical standpoint, for the nourishment of infants under one year of age.

In a study of the analyses of these proprietary foods as listed, and as analyzed by American, Canadian and English chemists, the objection to the nonstarchy proprietary baby foods is that they are either deficient in fat or in available salts or mineral matter, or both. The objection to the others is that they contain too much starch. Stewart says that the frequent connection between rickets and deficiency in fat is an undeniable clinical fact. Doctor Schereschewsky says that the proprietary infant foods and condensed milk, which are anything but rich in fat and available mineral matter, are themselves the most prolific causes of infantile scurvy. Cantley's conclusions in regard to proprietary baby foods which contain a high per cent of starch are that, first, a diastasic ferment is secreted by the salivary glands and pancreas of new-born infants; this salivary secretion, however, is scanty in young infants and rarely appreciable before the age of two months. Second, barley water contains about 2 per cent of starch; mixtures containing this per cent of starch are not injurious, but may be beneficial for the growth of lactic acid bacilli, and the formation of lactic acid bacilli are thereby encouraged. These organisms are of undoubted advantage in the prevention of the growth of proteolytic bacteria. Third, the evil-effects of starch in early life are due to, (*a*) excess, (*b*) its administration in the form of a more or less insoluble emulsion instead of a soluble starch, (*c*) the substitution of starch for the necessary protein, fat and salts. From Cantley's conclusions it is self-evident that the majority of proprietary foods for infants which contain large amounts of starch, even when they are diluted for use, are harmful. From various analyses of American, English and Canadian analysts, the following contain great excesses of starch:

Starchy Baby Foods.

TABLE I.

Allensbury's Malted Food No. 3	—66.3 per cent wheat starch;
Benger's Food for Infants	—59.57 per cent wheat starch;
Chapman's Food	—greater per cent of carbohydrates are wheat starch;
Carnick's Food	—16.20 per cent wheat starch;
Eskay's Food	—28.41 per cent raw arrowroot starch;
Frame's Food	—greater per cent of carbohydrates due to wheat starch;
Fessenden's Food	—35.69 per cent arrowroot starch;
Neave's Infant Food	—greater part of carbohydrates due to wheat starch;
Nestle's Food	—35.34 per cent wheat starch;
Ridge's Food	—70.73 per cent wheat starch;
Sunbright's California Baby Food	—63.25 per cent barley starch;
Imperial Granum	—76.60 per cent wheat starch; and
Lactated Food	—41.94 per cent wheat starch.

Those foods for infants that contain no starch, but are either deficient in fat or in available mineral matter, or both, are:

Contain no Starch but Deficient in Fat or in Available Mineral Matter or Both.

TABLE II.

Horlick's Malted Milk;
Meadow's Malted Milk;
Wample's Milk Food;
Robb's Soluble Milk Food, (Elgin & Co.'s)
and condensed and evaporated milks.

R. Hutchinson says that it is often contended for these proprietary products that they are more easily digested than natural foods and that many of them exist because they are predigested. He says that the necessity for peptonizing foods is greatly exaggerated, and that in pathological chemistry pepsin is almost never absent from the gastric juice unless hydrochloric acid is also absent. If hydrochloric acid can be found in the stomach, pepsin is sure to be there too; there is, therefore, little necessity for predigested foods.

With all these objections as pointed out, there is still an economic objection to proprietary foods for infants. Most of them contain a ridiculously small amount of nournishment at the retail price paid. Hutchinson says that it is vastly more expensive to rear a child upon one of them than upon fresh or even condensed milk. Mention might be made of the retail price calculated per pound net of some of these proprietary foods for infants. These are tabulated, and calculated in the following table:

TABLE III.

Trade name of infant food.	*Calculated price paid per lb. net.*
Cow's milk at 4 cents per liquid pound (calculated on dry basis)	$0.31
Allenbury's Malted Milk No. 3	.32
Ridge's Food	.47
Sunbright's Baby Food	.58
Nestle's Food	.61
Imperial Granum	.74
Carnick's Food	.77
Lactated Food	.79
Elgin's Meadow Malted Food	.84
Fessenden's Food	.85
Horlick's Malted Milk	.87
Borden's Malted Milk	.87
Wampole's Food	.90
Benger's Food	.93
Eskay's Food	.95
Mellin's Food	1.49

The facts in Table 3 are given as if these proprietary baby foods have the same food value in calories per pound as cow's milk. Table 4 which

follows shows that this is far from being the case. It also demonstrates the economy in buying cow's milk instead of proprietary baby foods, as far as the food value in calories per pound is concerned:

TABLE IV.

$0.31 worth of cow's milk is equal in food value to

$0.44	worth of Allenbury's Malted No. 3;
.66	worth of Ridge's Food;
.78	worth of Nestle's Food;
.82	worth of Sunbright's Baby Food;
1.02	worth of Imperial Granum;
1.03	worth of Horlick's Malted Milk;
1.05	worth of Carnick's Food;
1.11	worth of Lactated Food;
1.12	worth of Elgin's Meadow Malted Milk;
1.13	worth of Borden's Malted Milk;
1.20	worth of Fessenden's Food;
1.24	worth of Wampole's Food;
1.28	worth of Eskay's Food;
1.31	worth of Benger Food;
2.09	worth of Mellin's Food.

The food value in calories per pound is obtained by multiplying the sum of the per cents of carbohydrates and protein by 18.6. To this product add the product of the per cent of fat multiplied by 42.2.

Holt in "Diseases of Infancy and Childhood," p. 243, quotes the following table with reference to occurrence of infantile scurvy:

Previous Food.

Breast milk	12 cases, alone in 10
Raw cow's milk	5 cases, alone in 4
Pasteurized milk	20 cases, alone in 16
Condensed milk	60 cases, alone in 32
Sterilized milk	107 cases, alone in 68
Proprietary infant's foods	214

The translator in the preface of Pierre Budin's French book, "The Nursling," says in regard to this table quoted: "The disease (infantile scurvy) may thus arise under all forms of feeding. I do not know of any recorded case of infantile scurvy arising from sterilized milk where systematic analysis showed the milk to have been consistently of good quality. It is the poverty of the milk and not its sterilization which causes the disease. In sterilized milk alone is safety, and it must be the basis of all artificial feeding. The importance of the quality of milk which is to serve as a food for infants need hardly be emphasized. But besides the purity and quality, the amount of the infant's daily diet must be supervised. The purest of milks, the sterile supply which flows from a mother's breast, given in excess, may cause fatal digestive troubles. Each medical man ought to regulate the feeding of all infants born under his charge. His calling demands it as a duty, his humanity as a right. Every practitioner should be a center for the protection of infant life."

I mention this quotation from Professor Budin's book because in America there is a great deal of prejudice against sterilized milk, for it is thought to give rise to infantile scurvy. The two authorities in France, Budin and Dufour, have used sterilized milk in infant feeding for many years, have reared innumerable infants on it, and yet they have not had a single case of infantile scurvy. Doctor Pierre Budin towers far above

any authority in France on infant feeding. You cannot but be impressed with the mass of statistics and tables by which he gives his arguments for the use of sterilized milk. His book, "The Nursling," with its ten lectures may be profitably studied.

Dr. Walter Lester Carr, in an introduction to the American edition of Doctor Budin's book, makes a criticism as follows: "These lectures are wanting in a description of what is known in America as the percentage method for modifying milk for infants and the calculations made on the basis of the use of whole milk sterilized may be questioned as unreliable from the standpoint of scientific infant feeding. Percentage modifications have no part in this book, as can be seen at a cursory glance, but the valuable part of the work is shown in an appreciation of the mortality of young infants both in and out of the hospital due to the inability of mothers to nurse their offspring and to the ignorance of the mothers in the esentials of artificial feeding. The care of the milk, the instruction to the mothers in methods of feeding and in cleanliness and the personal oversight exercised by the physicians under Doctor Budin's direction, had much to do with the improved health of the infants whose histories are recorded; sterilized milk was not alone responsible for the improvement. Sterilized milk was for Doctor Budin's purpose better than unsterilized stale milk, but putting aside any consideration of the relative values of unsterilized and sterilized milk for infants the fact remains that Doctor Budin presents in his course of lectures details of infant feeding and management that gave him good results and are of great clinical interest to all who are working with a definite purpose towards a goal of a lessened infantile morbidity and mortality."

Doctor Budin's theory is in short that the sterilization of cow's milk lessens the difficulties with the digestion of casein and he feels sure that infants fed with sterilized milk suffer less from rickets, scurvy, and intestinal disorders than infants fed in other ways.

Dennett in "Simplified Infant Feeding" (1915) says that in prescribing food for any infant, there are three main points for consideration. First: it should contain the proper elements to maintain nutrition and to allow growth; second: it should be digestible; and third: it should contain the proper quantity of food, which is best estimated by caloric standards. Dennett states that he believes and has proven to his satisfaction that any deficiency in fat may be made up by adding sugar. In support of this he says, "How else can one explain the splendid results obtained in feeding infants throughout the bottle period with a mixture containing far less fat than breast milk? For these reasons it is not necessary to use top-milk mixtures or to add cream to milk mixtures." Dennett also states in regard to proprietary baby food as follows: "If a proprietary food has been used, one must know what that proprietary food contains, in order not to repeat the error that has already caused digestive disturbances or malnutrition." Dennett's idea of proprietary foods for infants is that many of these foods are made up of ingredients which may be very properly used in infant feeding with great benefit to the individual infant—if the physician does not object to the use of a food that is advertised to the laity. Further he says, however, that these foods should be

intelligently used and not merely according to a set of general formulas which the manufacturer prepares. In other words, he says that the physician should be equipped with a sufficient understanding of infant feeding to construct each formula to suit the needs of the individual patient. If, for instance, a food is used that is composed of malt sugar, a sufficient knowledge of infant feeding would indicate the exact amount of milk and water necessary to be added to this food.

Dennett says that since cow's milk was intended for the calf such measures of modification or dilution must be taken in order to adapt it to the human infant's digestion.

L. Emmett Holt, M. D., LL. D., professor of diseases of children in the College of Physicians and Surgeons (Columbia University), in his book on "The Care and Feeding of Children," says: "Scurvy is a disease of general nutrition, usually caused by the long continued use of improper food. Most of the cases come from the use of the prepared infant's foods sold in the stores, especially when they are given without fresh milk; occasionally the use of condensed milk and of sterilized milk is followed by scurvy; sometimes it is seen when, owing to feeble digestion, it has been necessary to make cow's milk very weak for a long time—If not recognized, or untreated, it may cause death."

In a book on nursing by Amy E. and Thirza A. Pope they say that rickets is supposed to be due to a lack of fat, proteid food, and salts in the diet. The prevention is food rich in mineral matter, as fruit juices, and, if the child is old enough, vegetables and rare or uncooked beef, milk, eggs, etc. Starches are restricted.

TABLE SHOWING AVERAGE ANALYSES, ALL SOURCES—FOODS FOR INFANTS.

Name of Food.	Per cent fat.	Per cent mineral matter or ash.	Per cent protein (Nx6.25).	Per cent carbo-hydrates.	Per cent water.	Remarks as to principal carbohydrates.
Allenbury's No. 3	0.87	1.01	11.47	81.66	5.31	Wheat starch, lactose, maltose and malt.
Benger's	0.83	1.07	12.00	78.49	8.61	Raw wheat starch.
Borden's Malted	6.14	3.17	13.38	71.89	5.42	Converted starch and lactose.
Carnick's	1.69	2.79	15.86	78.99	3.46	Wheat starch and milk sugar.
Chapman's	1.98	1.64	12.75	74.26	9.37	Wheat and starch.
Eskay's	1.20	1.34	6.56	87.84	3.06	About equal parts raw arrowroot, starch and milk sugar.
Frame's	0.46	1.52	13.31	81.34	3.37	Baked wheat starch, maltose, dextrose and cane sugar.
Fessenden's	0.40	1.60	6.00	86.05	5.95	About equal parts raw arrowroot, starch and dextrose.
Horlick's Malted	5.80	3.64	13.73	76.83	3.25	Dextrose, malt, lactose and active diastace.
Meadow Malted (Elgin's)	4.11	3.22	13.88	74.75	4.04	Dextrose and lactose.
Mellin's	0.55	3.49	11.43	80.33	4.20	Maltose.
Neave's	0.91	0.68	13.44	79.57	5.40	Wheat starch.
Nestle's	5.10	1.92	11.14	78.99	2.85	Dextrose and wheat starch.
Ridge's	0.95	0.70	12.21	78.79	7.35	Raw wheat starch.
Robb's	14.50	3.46	14.31	65.21	2.52	Milk sugar due to dried milk.
Sunbright's	0.70	1.09	7.94	81.75	9.00	Barley starch, small amount dextrose.
Wampole's	4.53	4.98	15.31	69.01	6.17	Milk sugar.
Imperial Granum	0.58	0.47	13.45	79.55	5.95	Wheat starch.
Condensed Milk, sweetened (dry basis)	14.33	1.76	11.38	72.53	.....	Due to original 41.92% cane sugar and 11.97% milk sugar.
Condensed Milk, unsweetened (dry basis)	28.76	5.50	30.75	34.99	.....	Due to original 9.85% milk sugar.
Cow's Milk (dry basis)	28.59	5.57	27.87	37.97	.....	Due to milk sugar and lactose.
Human Milk (dry basis)	30.02	2.46	18.18	49.34	.....	Due to milk sugar and lactose.

CONCLUSIONS.

1. When we stop to study the composition of the majority of proprietary foods for infants we are impressed with the fact that they are comparatively useless and *in some cases harmful to children under one year of age.*

2. There is no doubt but that the use of these kinds of foods for infants sets up a disturbance of the child's delicate digestive organs. First, because of an excess of starch in an insoluble emulsion. Second, the lack of available mineral salts. Third, because of the deficiency in fat, which is needed for fuel value.

3. Most investigators have agreed that cow's milk is the only food supply, apart from mother's milk, that is available in this country, from a practical standpoint, for the nourishment of infants under one year of age.

4. Eminent specialists say that there is little necessity for predigested foods.

5. From analyses by American, English and Canadian chemists, it is proven that there is no proprietary food for infants on the market that can anywhere near compare with cow's milk as a substitute for woman's milk, especially in the physiological fuel value.

6. The deficiency in fat and available mineral matter in most of these proprietary foods for infants may give rise to rickets or to infantile scurvy.

7. The economic question is at issue in that most of these proprietary foods for infants contain a ridiculously small amount of nourishment at the retail price paid.

8. The majority of claims for proprietary foods for infants are largely fallacious.

9. The heating required in the making of condensed or evaporated milk or in the making of milk powders or proprietary foods for infants which contain dried milk destroys the important enzymes which are said to have anti-scorbutic properties. In other words, *excessive heat* kills the milk enzymes naturally found in raw milk, which are said to have a tendency to prevent scurvy. This does not mean that heated or sterilized milk will cause scurvy, but scurvy may be prevented if *excessive heat* is not used.

10. Investigators have proven that even in a ten per cent solution of these proprietary foods for infants, a homogeneous mixture cannot be obtained. In some of the products which contain starch, this is due to a formation of a pasty or emulsified condition due to the swelling of the starch grains.

11. Proprietary infant foods should never be used except on a physician's advice. Such products are not for the laity to use according to manufacturer's formula. They are as bad a menace to the public as so-called patent medicines. One should know what is needed for the child before feeding a food that has no advantage over good cow's milk.

Topeka, Kansas.

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